

DESIGN OF SINGLE COLUMN BENTS FOR 2-SPAN BOX GIRDER BRIDGES

Single column, two-span prestressed box girder bridge columns, which meet the following requirements, should be designed using the attached charts. If these requirements are met, it is not necessary to perform a STRUBAG, STRUDL, SEISAB or simplified analysis to determine the column reinforcement. The designer is cautioned to review the limitations to assure that the charts apply. Column sizes may be approximately round with a cross-sectional area of 20 sq. ft. (5 ft. dia.) or 28 sq. ft. (6 ft. dia.). Intermediate cross-sectional areas may be used by interpolating between the two charts. Columns may be prismatic or nonprismatic with a single diameter spiral core.

Limitations

Depth to span ratio	0.035 to 0.045
Column height	18 to 26 feet clear
Column area at base	20 to 28 sq. ft. (5 to 6 ft. dia.)
Span length	100 to 240 feet
Maximum skew	35 degrees
Maximum unbalance in spans	20%
Minimum radius of centerline	1000 ft.
Bridge width	32 to 46 feet
Column end conditions	"fixed" top and bottom
Column concrete	$f_c' = 3250 \text{ psi}$
Column reinforcement	$f_y = 60,000 \text{ psi}$
Column must be centered under cap	

After the column reinforcement has been determined from the charts, run the YIELD program in check mode for Group I loads only. Column shear reinforcement shall be determined from the plastic load case. The footing is then designed for only the Group I and plastic load cases.

An example problem showing the design of a typical single column bent is attached.

Discussion

The load conditions which governed the design of the columns were P-loads and seismic.

Seismic loads generally governed the 6 foot diameter column designs, except the P-loads governed the design of narrow width structures in the 0.5 – 0.6g seismic level.

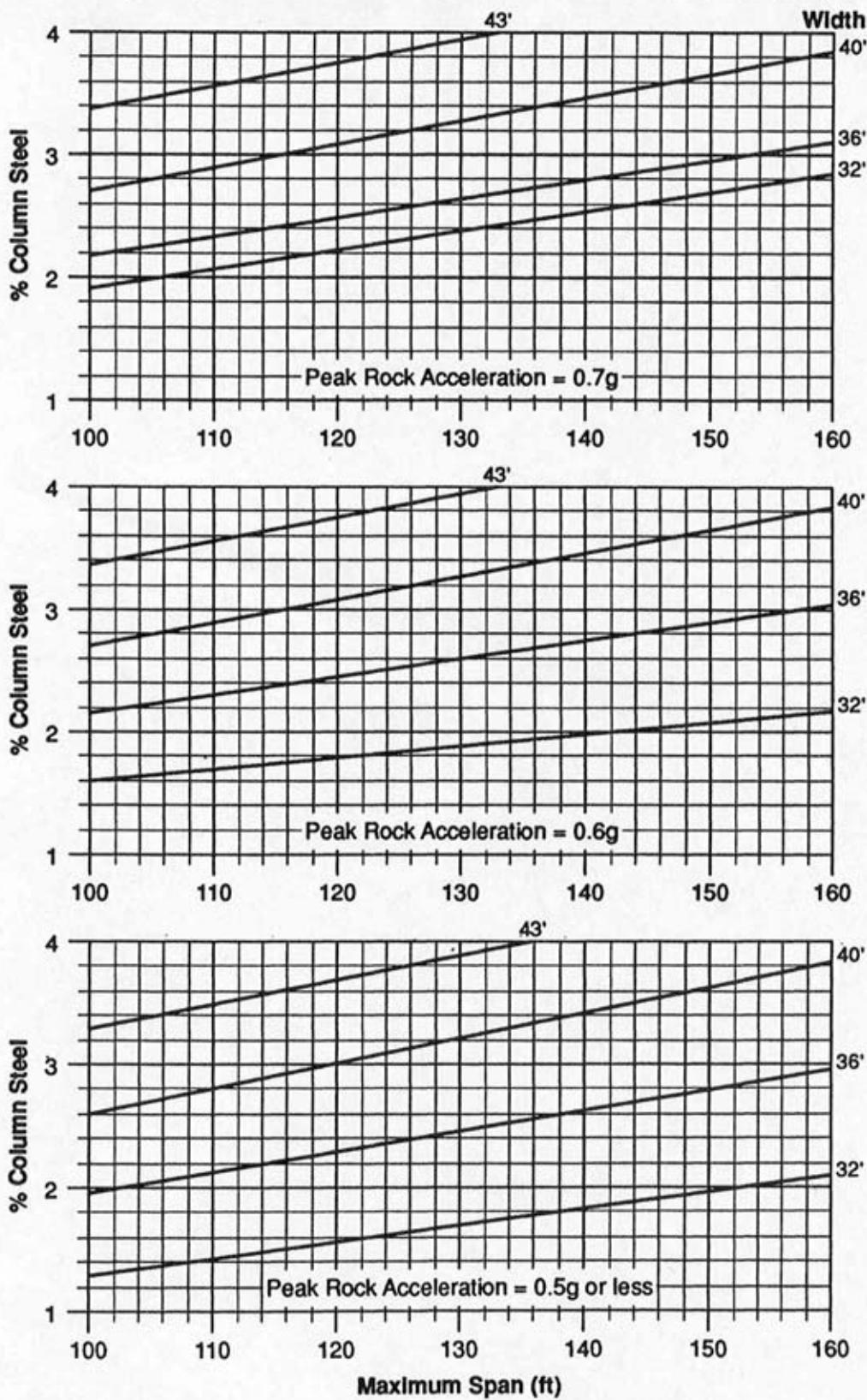
The design of the 5 foot diameter column was generally governed by P-loads, except for the narrow structures, which were governed by seismic loads. Note that the 5 foot diameter column generally requires a much larger percentage of steel than the equivalent 6 foot diameter column. The use of the 5 foot diameter column should be restricted to narrow structures in the low span length range.

Standard abutment and wingwall details are assumed (refer to applicable drawings). It is assumed that under the maximum credible earthquake the abutments will be damaged and undergo some movements. In these charts, the abutments were considered released in the transverse direction and soil support assumed in the longitudinal direction, therefore it is important that standard abutment heights and berms be used to preclude a collapse condition.

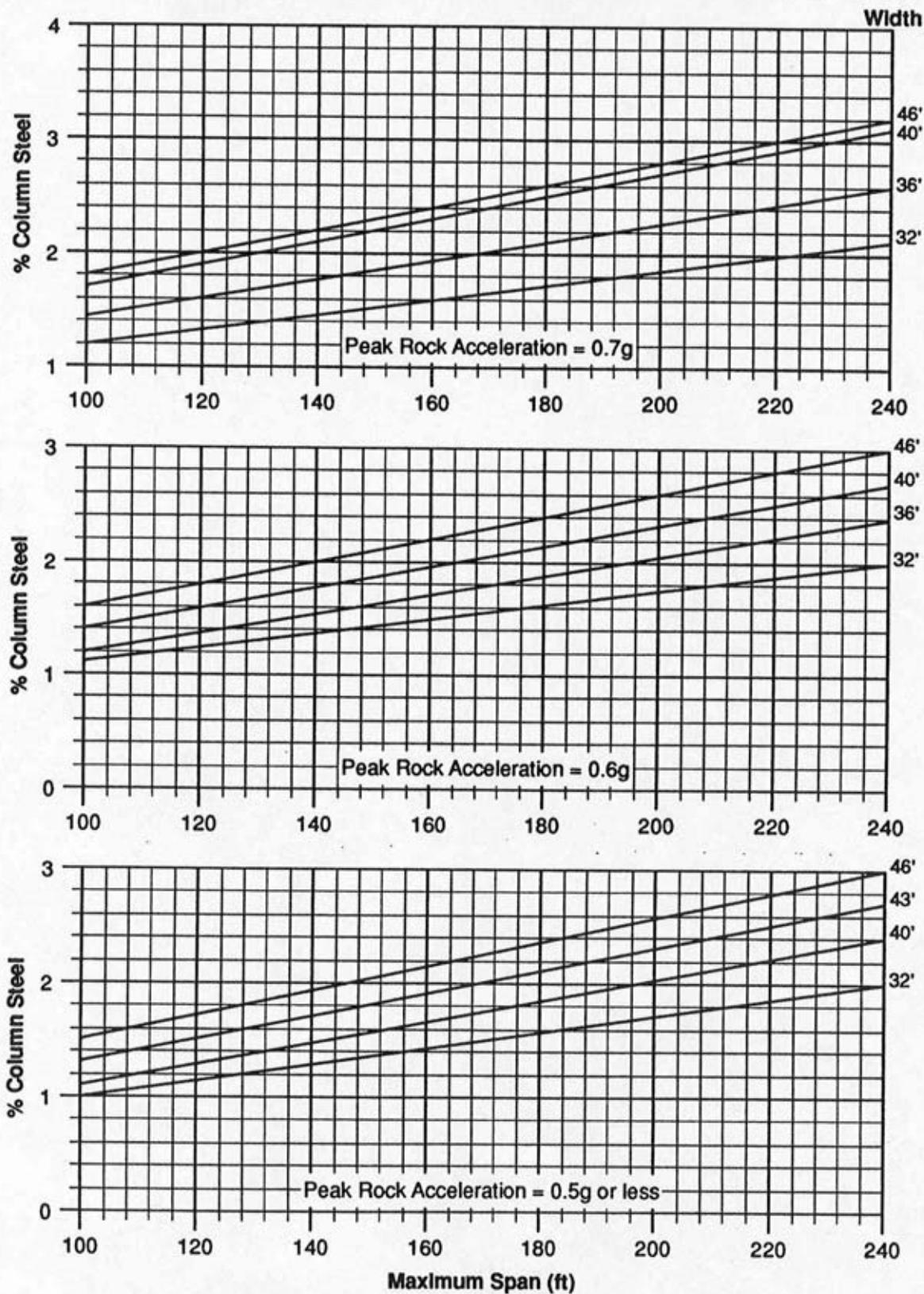
Abutment seat and key sizes shall be determined as outlined in Memo to Designers, Section 5.

It is hoped that this series of charts will be expanded to include other common bridge configurations. Please direct any comments or suggestions to J. Gates in the SASA section.

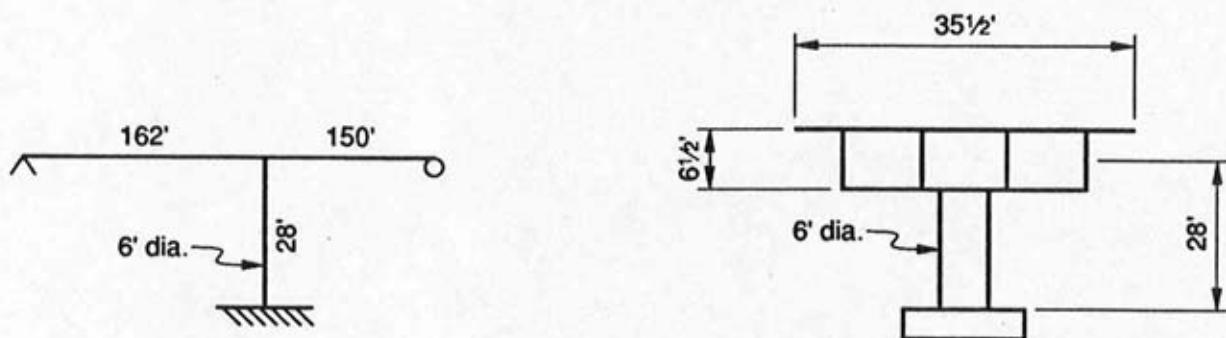
**Column Reinforcement for Prestressed Box Girders
2 Spans, 1 Column Bent – 5' Diameter Column (20 Sq. Ft.)**



Column Reinforcement for Prestressed Box Girders
2 Spans, 1 Column Bent – 6' Diameter Column (28 Sq. Ft.)



2 Span – 1 Column
Example Column/Footing Design (using STD charts)



"A": Rock Acceleration = 0.6g

Verify Applicability of Charts

ITEM	ALLOWANCE	ACTUAL	
D/S	0.035 – 0.045	0.040	OK ✓
Column Clearance Height	18' – 26'	24.8'	OK ✓
Column Area	20 – 28 ft. ²	28.3 ft. ²	OK ✓
Maximum Span	100' – 240'	162.0'	OK ✓
Span Unbalance	0.20	0.08	OK ✓
Width	32' – 46'	35.5'	OK ✓
Alignment	1000' R	Straight	OK ✓
Skew	35°	0°	OK ✓

Determine Column Reinforcement from Charts

$$\left. \begin{array}{l} A = 0.6g \\ W = 35.5' \\ \text{Span} = 162' \\ \text{Column Area} = 28 \text{ ft.}^2 \end{array} \right\} = 1.7\%, A_s = 28.3 (144) 0.017 = 69.3 \text{ in.}^2$$

Select Bar and Number

Approximate Spacing

#11 tot 44	4.8"
#14 tot 30	6.8" ← use
#18 tot 17	12.3"

Group Loads (Bottom of Column)

DL (From BDS)
 (Bottom of Column) $M_y(\text{Trans}) = 0$
 $M_x(\text{Long}) = 57' \text{ k}$
 $P(\text{Axial}) = 1979' \text{ k}$

$$\text{Live Load Lanes on Bent} = \frac{35.5 - 3.5}{12} = 2.67 \quad \text{use 2 lanes}$$

BDS Output

LL No. 1 (H Loads)

Live Load Support Results (1 Lane — LL + I)

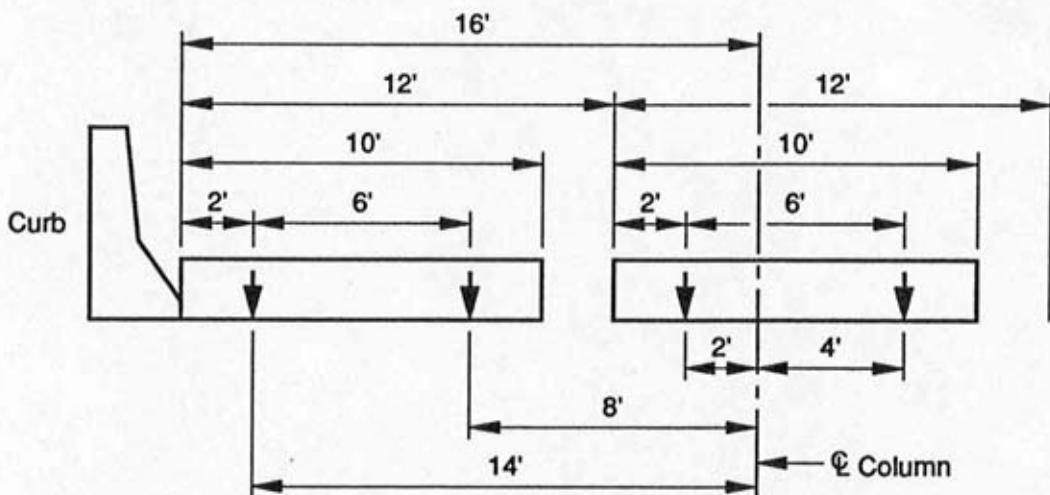
	Maximum Axial Load			Maximum Longitudinal Moment		
	Axial Load	Moment		Axial Load	Moment	
		Top	Bottom		Top	Bottom
Support Jt. 1						
Positive	80.2	0.0	0.0	0.0	0.0	0.0
Negative	-5.8	0.0	0.0	0.0	0.0	0.0
Member 3						
Positive	179.3	132.0	-66.0	94.8	1241.0	-620.0
Negative	0.0	0.0	0.0	87.8	-1092.0	546.0
Support Jt. 3						
Positive	77.9	0.0	0.0	0.0	0.0	0.0
Negative	-7.7	0.0	0.0	0.0	0.0	0.0

LL No. 4 (P Loads)

Live Load Support Results (1 Lane — LL + I)

	Maximum Axial Load			Maximum Longitudinal Moment		
	Axial Load	Moment		Axial Load	Moment	
		Top	Bottom		Top	Bottom
Support Jt. 1						
Positive	222.0	0.0	0.0	0.0	0.0	0.0
Negative	-16.1	0.0	0.0	0.0	0.0	0.0
Member 3						
Positive	348.1	340.0	-170.0	260.2	3692.0	-1846.0
Negative	0.0	0.0	0.0	250.5	-3319.0	1660.0
Support Jt. 3						
Positive	214.5	0.0	0.0	0.0	0.0	0.0
Negative	-7.7	0.0	0.0	0.0	0.0	0.0

Live Loads



Live Load Position on Cap

H Loads – Case 1 (Maximum Transverse) (1 Lane)	$M_y = 179.3(8 + 14)/2$	= 1972' k
	M_x	= 66' k
	P	= 179' k
H Loads – Case 2 (Maximum Longitudinal) (2 Lanes)	$M_y = 94.8(8 + 14 + 2 - 4)/2$	= 948' k
	$M_x = 620(2)$	= 1240' k
	P = 94.8(2)	= 190' k
H Loads – Case 3 (Maximum Axial) (2 Lanes)	$M_y = 179.3(8 + 14 + 2 - 4)/2$	= 1793' k
	$M_x = 66.0(2)$	= 132' k
	P = 179.3(2)	= 359' k
P Loads – Case 1 (Maximum Transverse) (1P)	$M_y = 348.1(1.15)(8 + 14)/2$	= 4403' k
	$M_x = 170.0(1.15)$	= 196' k
	P = 348.1(1.15)	= 401' k
P Loads – Case 2 (Maximum Longitudinal) (1P + 1H Lane)	$M_y = 260.2(1.15)(8 + 14)/2 + 94.8(2-4)/2$	= 3197' k
	$M_x = 1846(1.15) + 620$	= 2743' k
	P = 260.2(1.15) + 94.8	= 394' k
P Loads – Case 3 (Maximum Axial) (Same as P Loads – Case 1 plus 1H Load)	$M_y = 348.1(1.15)(8 + 14)/2 + 179.3(2 - 4)/2$	= 4223' k
	$M_x = 170.0(1.15) + 66$	= 262' k
	P = 348.1(1.15) + 179.3	= 580' k

(Note: These numbers may also be obtained from a BENT analysis run.)

Use YIELD program to:

- (a) Determine Column Shear Reinforcement
- (b) Generate Footing Loads

YIELD Input	72" Diameter Column
	Check Mode
	Generate Footing Loads
	Out-Out Spiral = 72" - 4" = 68"
	(#6) (#14)
	Use #14 Tot 30 Loop Radius = 68/2 - 0.875 - 1.875/2 = 32.2"
Impact 17.5% from BDS	
Clear Length = 24.8'	

YIELD Output – Longitudinal Plastic Case Governs

Maximum Center-to-Center Spacing (Pitch) of Lateral

Bar Size	Case A	Case B	Case C
	Confinement	Applicable Shear	Minimum Shear
4	2.613	1.290	7.059
5	4.042	1.999	10.941
6	5.722	2.838	15.529

Minimum Spacing → Bar Size	1.0" Aggregate	Shear Strength (kips)
	Minimum Pitch (inches)	
4	2.000	913
5	2.125	1168
6	2.250	1444

↑ ↑

Note: Always use 1" Aggregate Use #6 @ 2³/₄" Pitch

**COLUMN INTERACTION GRAPHS
FOR STANDARD ARCHITECTURAL SIZES**

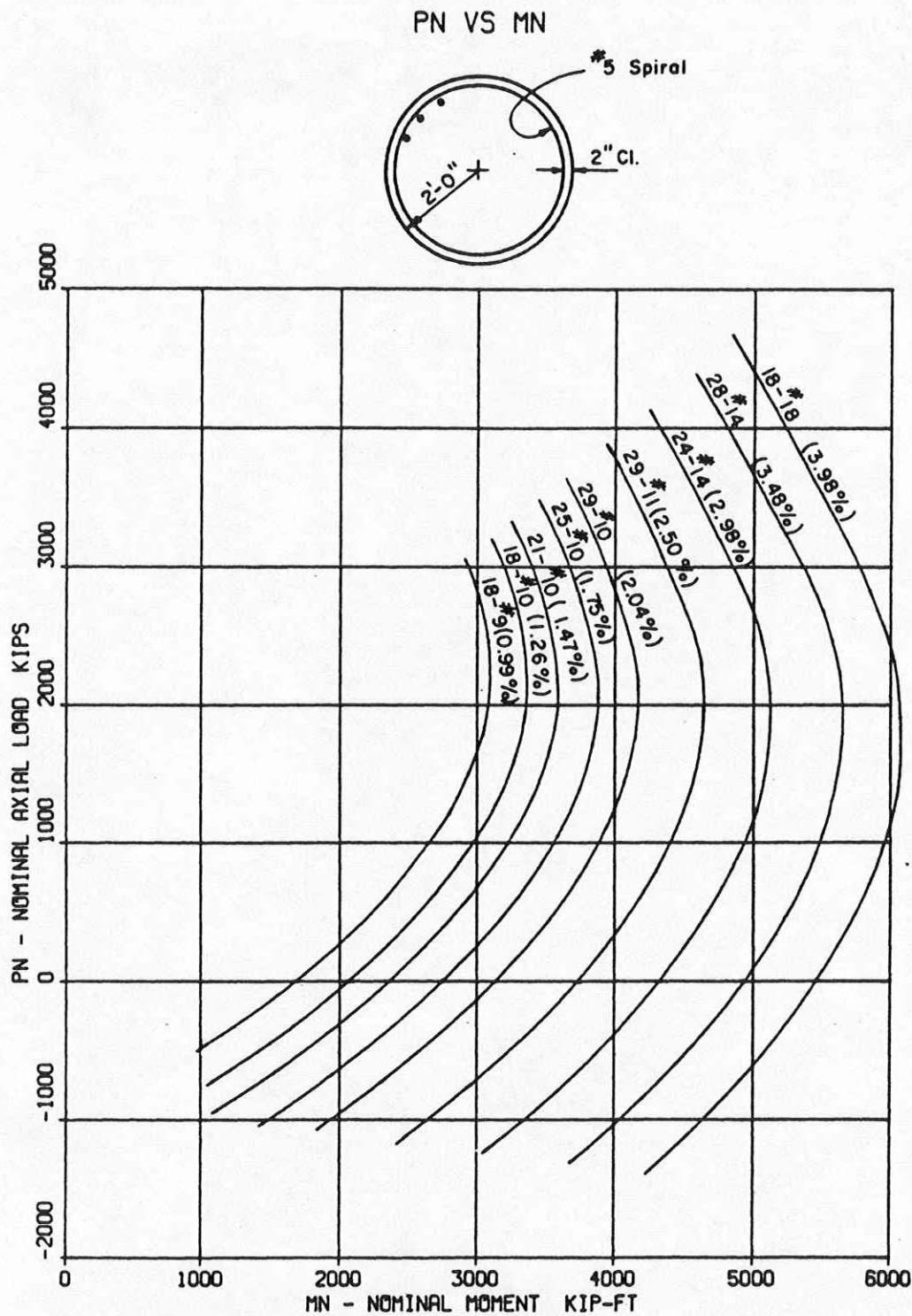
Column Type	Pages
Round - 4'Ø, 5'-6"Ø and 7'Ø	13-11
Octagonal - 4'Ø, 5'-6'Ø and 7'Ø	13-14
Hexagonal - 4'Ø, 5'-6"Ø and 7'Ø	13-17
Square - 4', 5'-6" and 7'.....	13-20
4'-0" × 6'-0"	13-24
5'-6" × 8'-3"	13-40
7'-10" × 10'-6"	13-52

The graphs may be used to determine the nominal strength of column as required to design substructures and foundations by the load factor design procedure.

Assumptions:

- Specified Concrete Compressive Strength $f'_c = 3250 \text{ psi}$
- Specified Yield Strength of Reinforcement $f_y = 60.0 \text{ ksi}$

Blank Page (13-10)

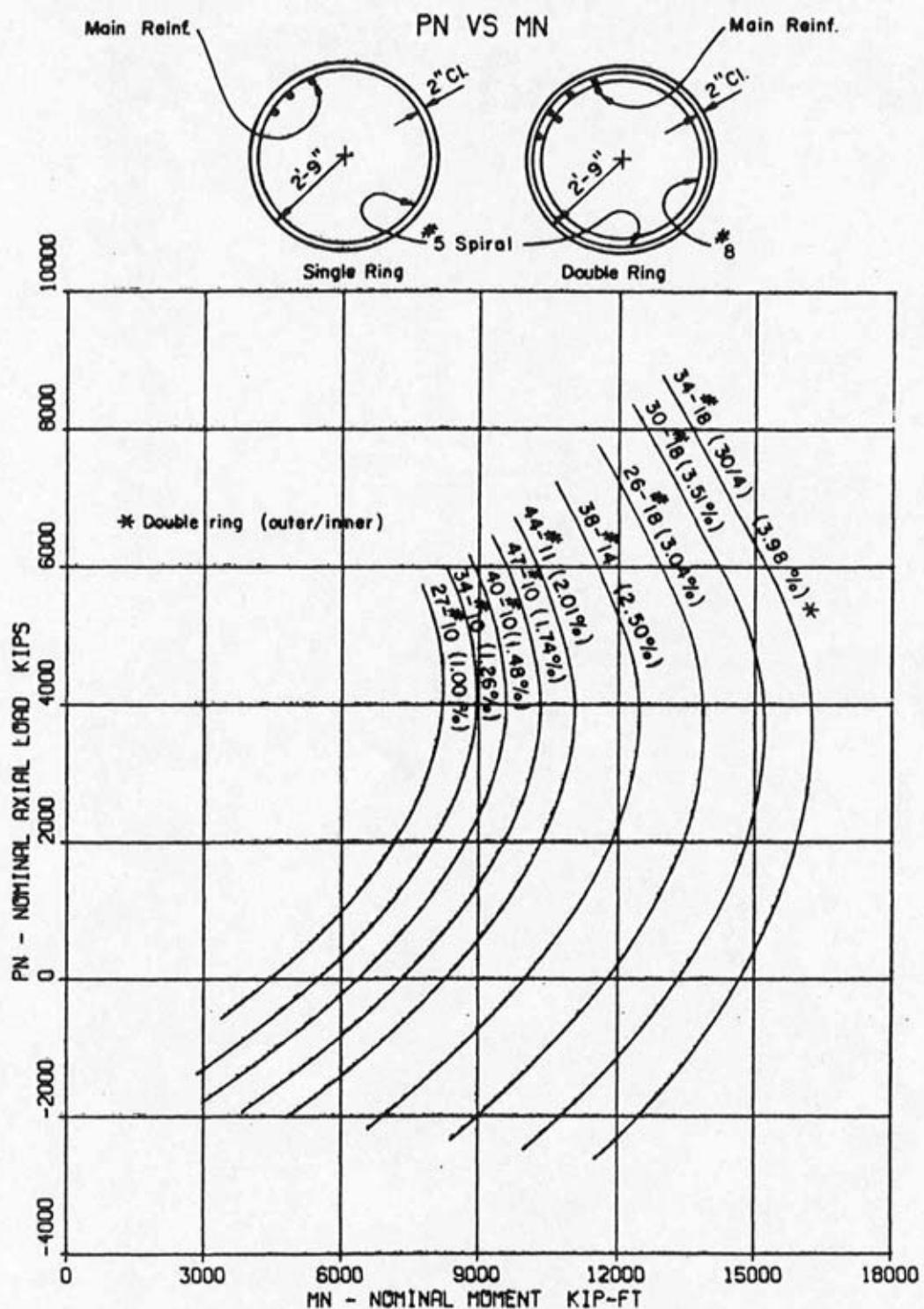


$$A = 12.6 \text{ ft}^2$$

$$I = 12.6 \text{ ft}^4$$

$$I_z = 25.1 \text{ ft}^4$$

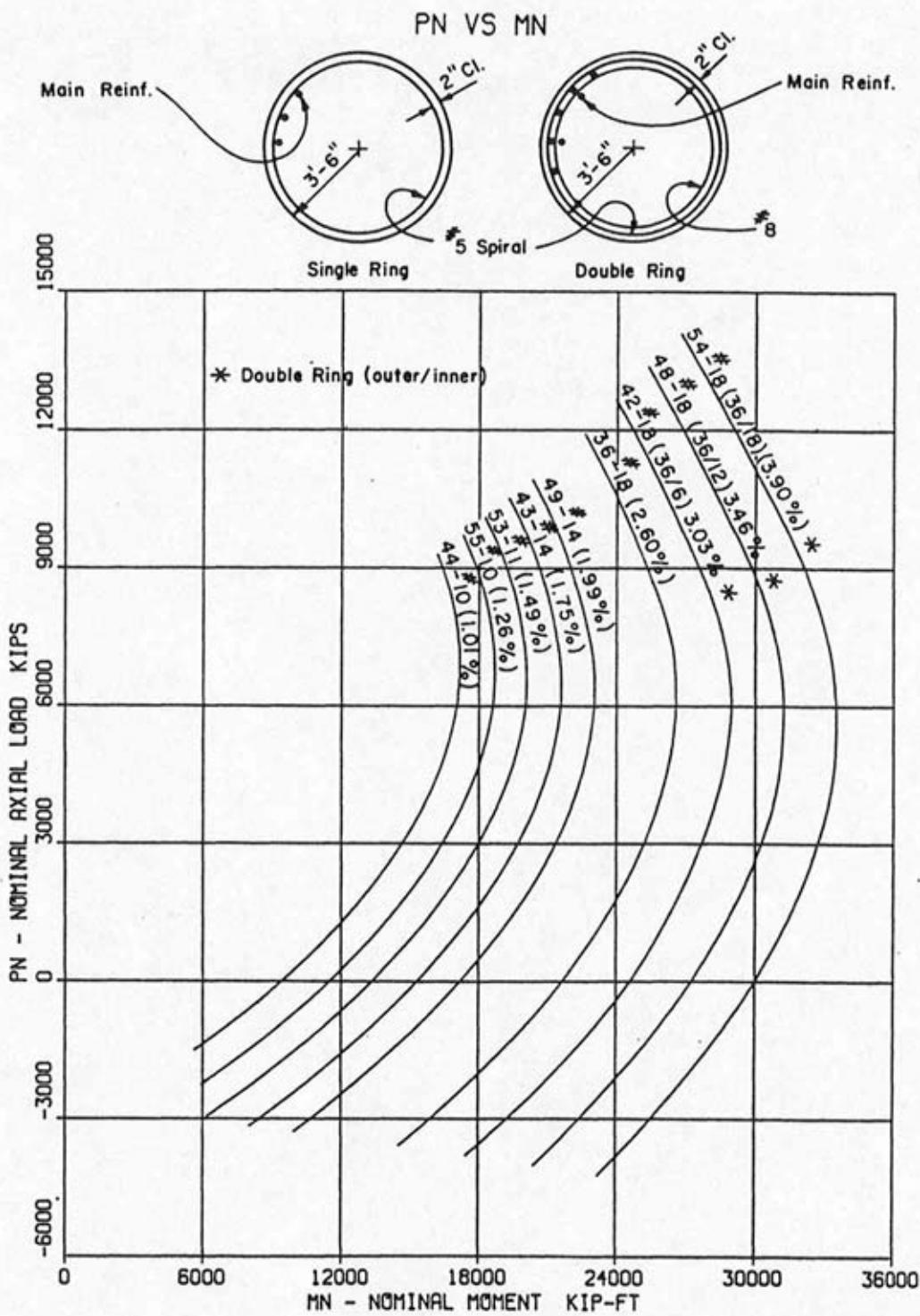
z = Local member longitudinal axis



$$A = 23.8 \text{ ft}^2$$

$$I = 44.9 \text{ ft}^4$$

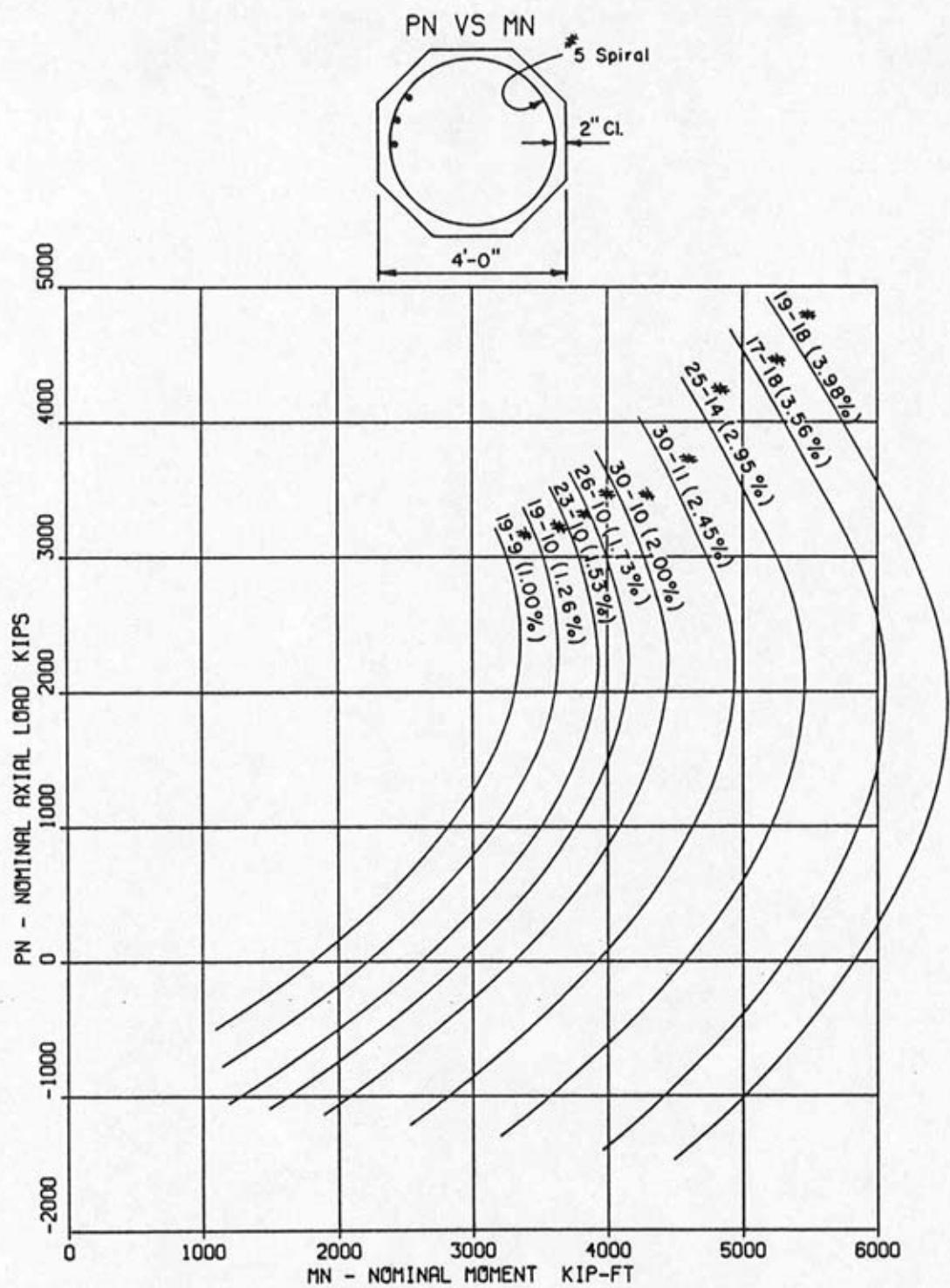
$$I_z = 89.8$$



$$A = 38.5 \text{ ft}^2$$

$$I = 117.8 \text{ ft}^4$$

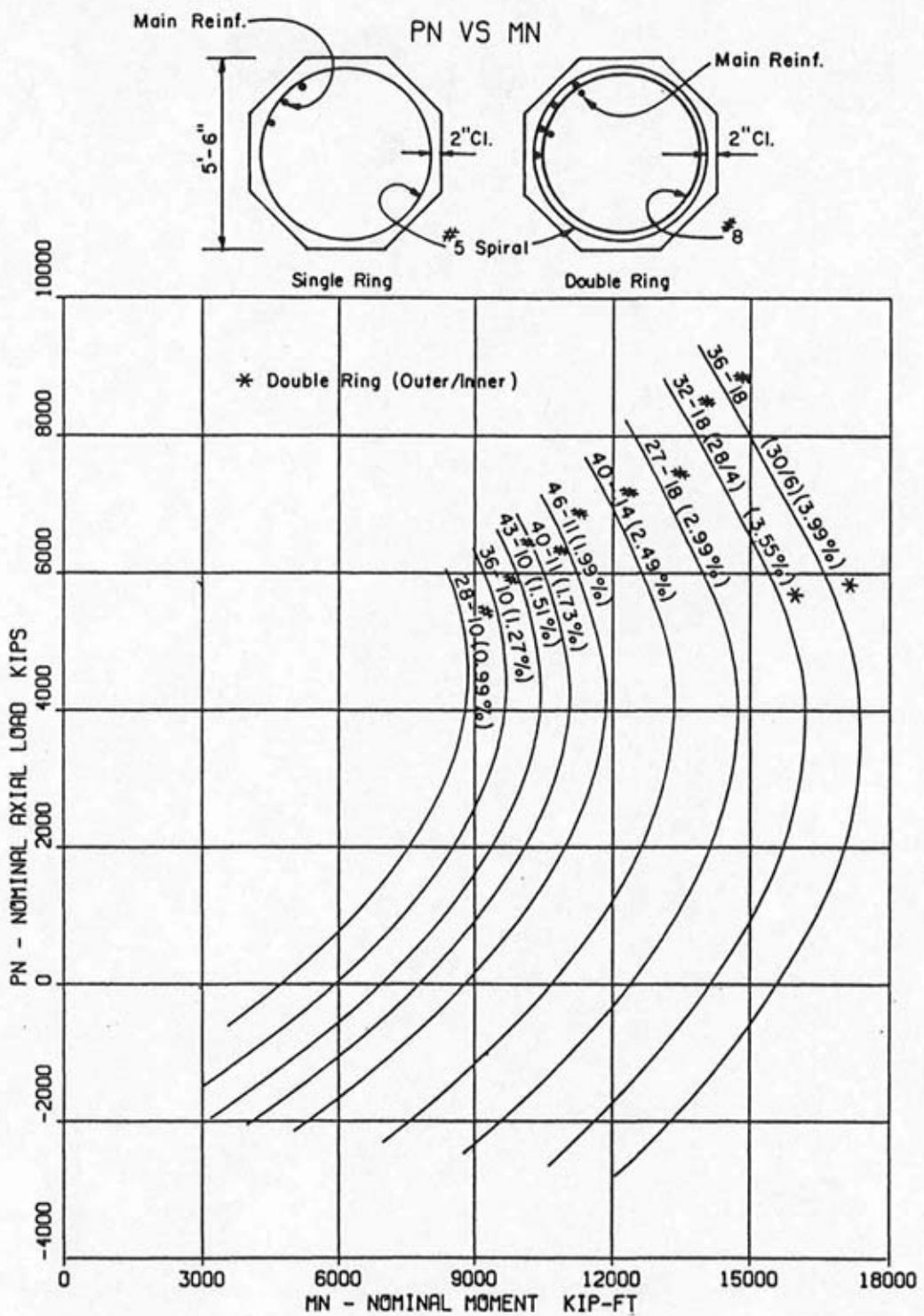
$$I_z = 235.7 \text{ ft}^4$$



$$A = 13.3 \text{ ft}^2$$

$$I = 14.0 \text{ ft}^4$$

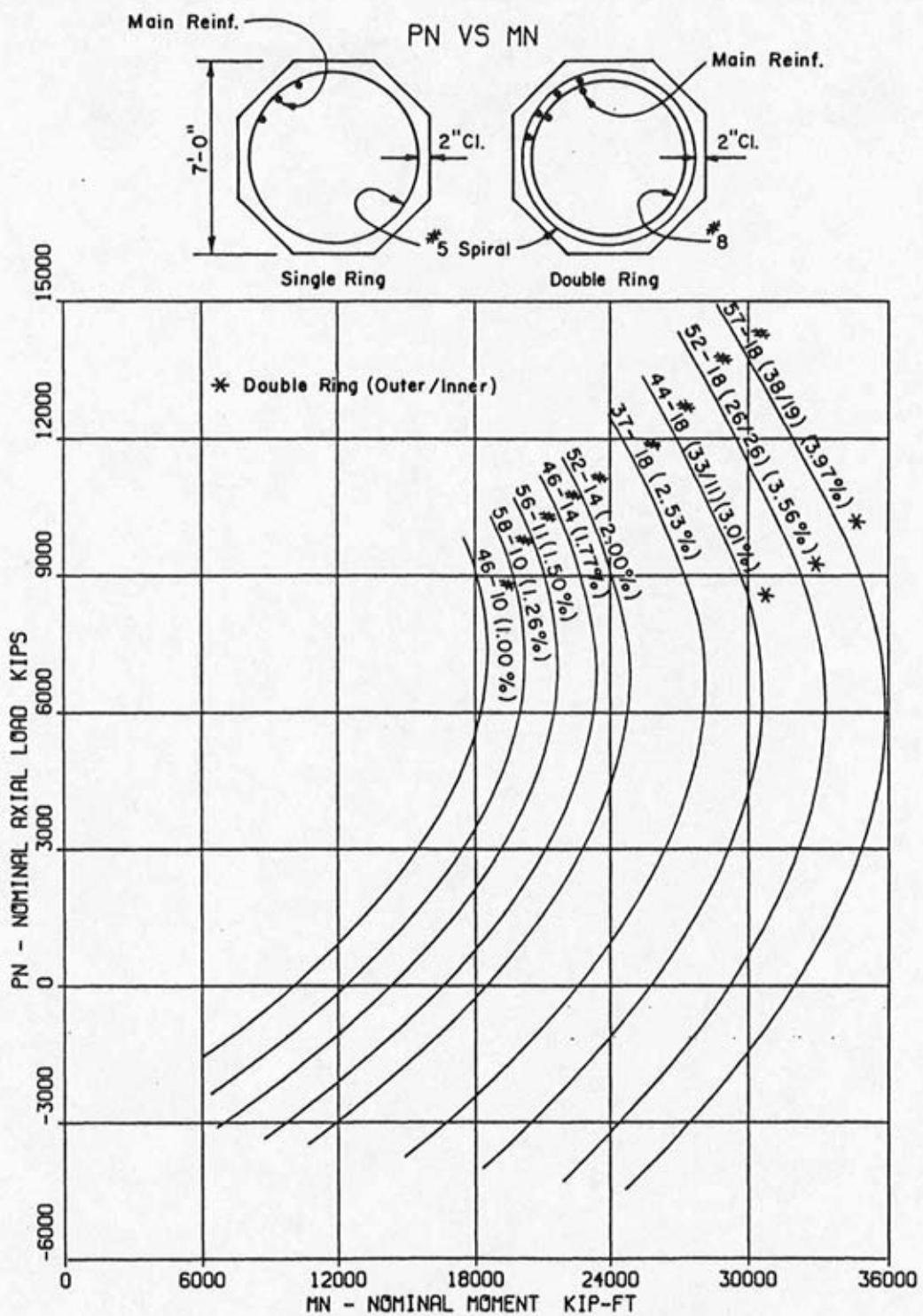
$$I_z = 28.1 \text{ ft}^4$$



$$A = 25.1 \text{ ft}^2$$

$$I = 50.1 \text{ ft}^4$$

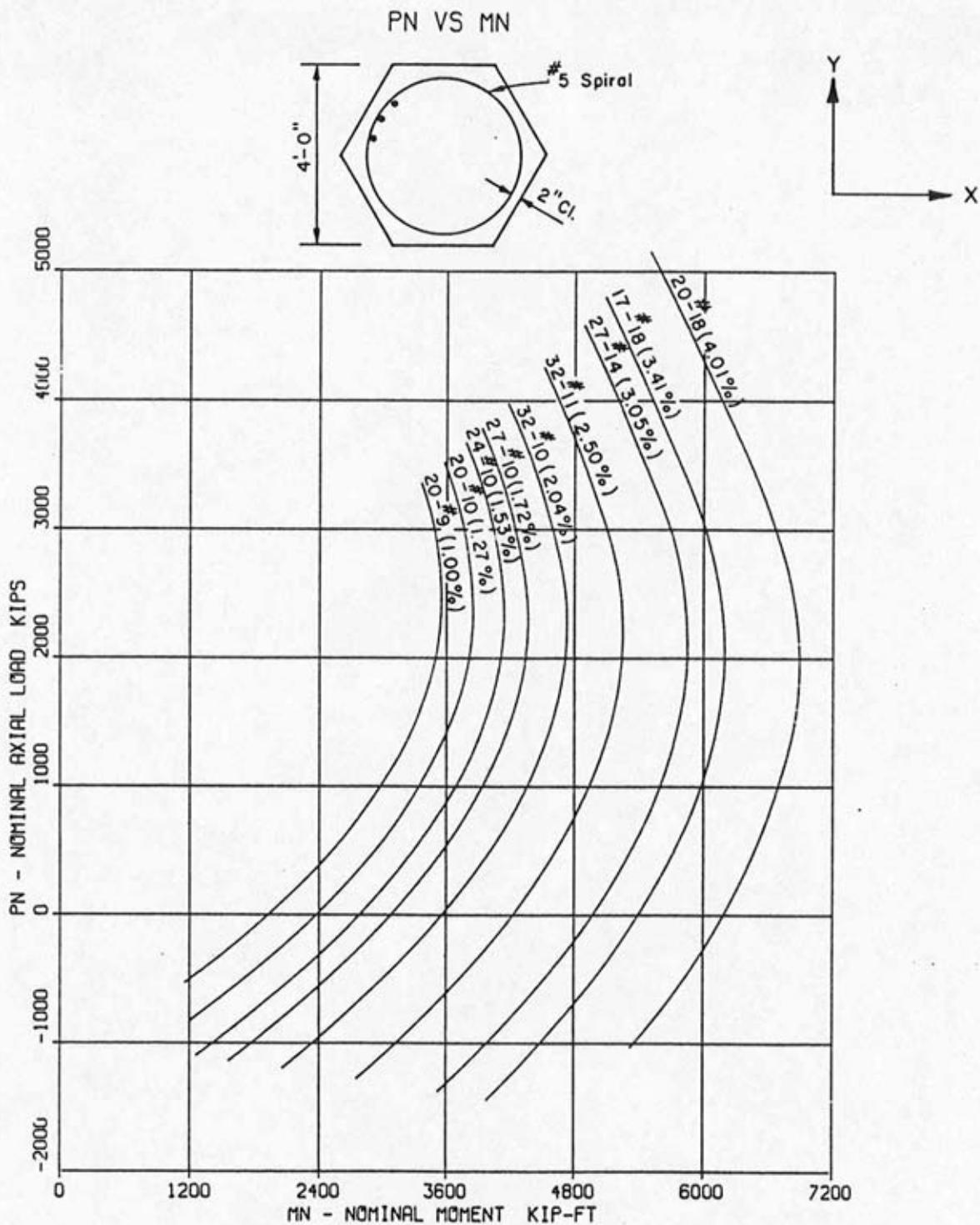
$$I_z = 100.2 \text{ ft}^4$$



$$A = 40.6 \text{ ft}^2$$

$$I = 131.4 \text{ ft}^4$$

$$I_z = 262.9 \text{ ft}^4$$

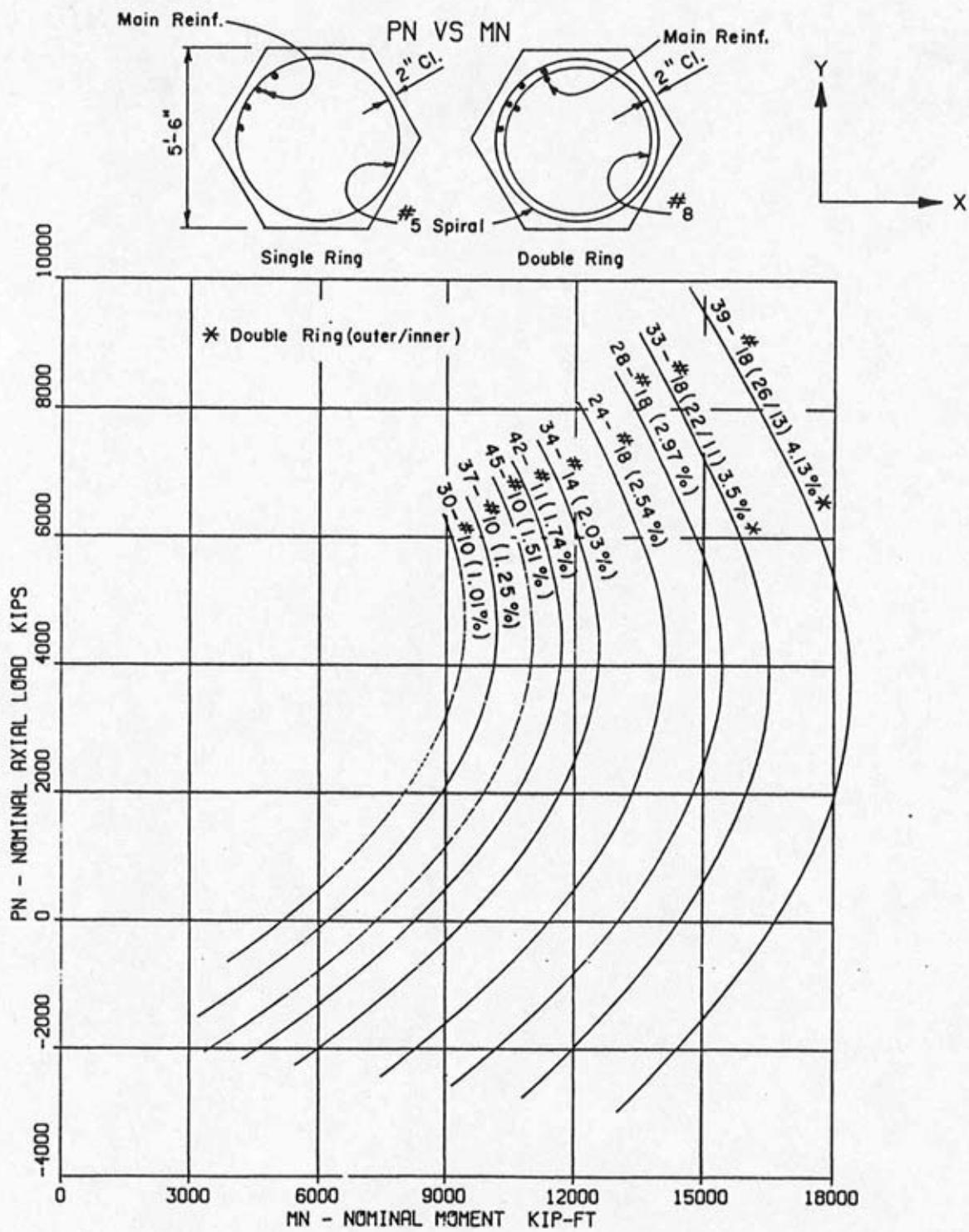


$$A = 12.0 \text{ ft}^2$$

$$I_x = 13.3 \text{ ft}^4$$

$$I_y = 10.0 \text{ ft}^4$$

$$I_z = 23.3 \text{ ft}^4$$

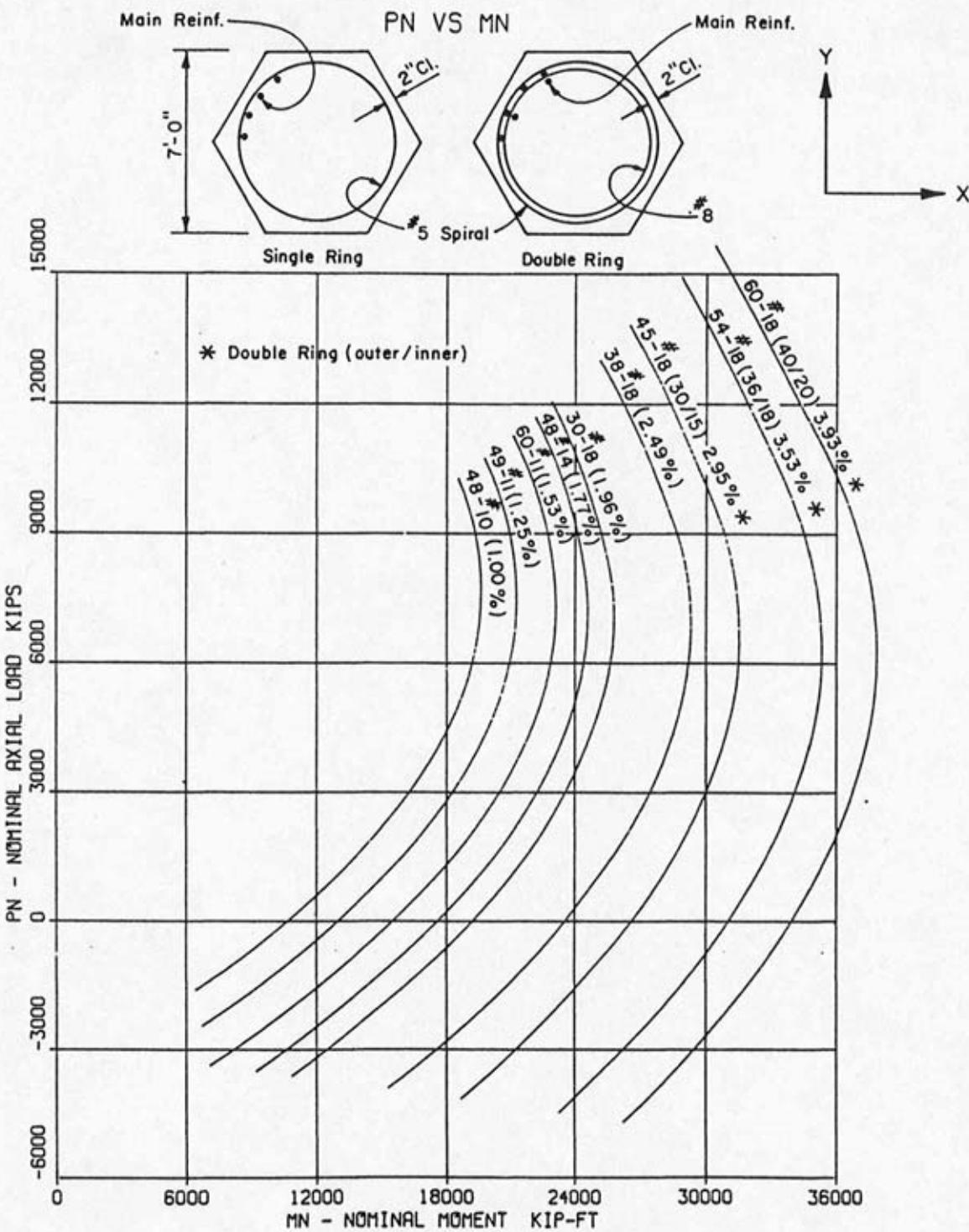


$$A = 22.7 \text{ ft}^2$$

$$I_x = 47.7 \text{ ft}^4$$

$$I_y = 35.7 \text{ ft}^4$$

$$I_z = 83.4 \text{ ft}^4$$

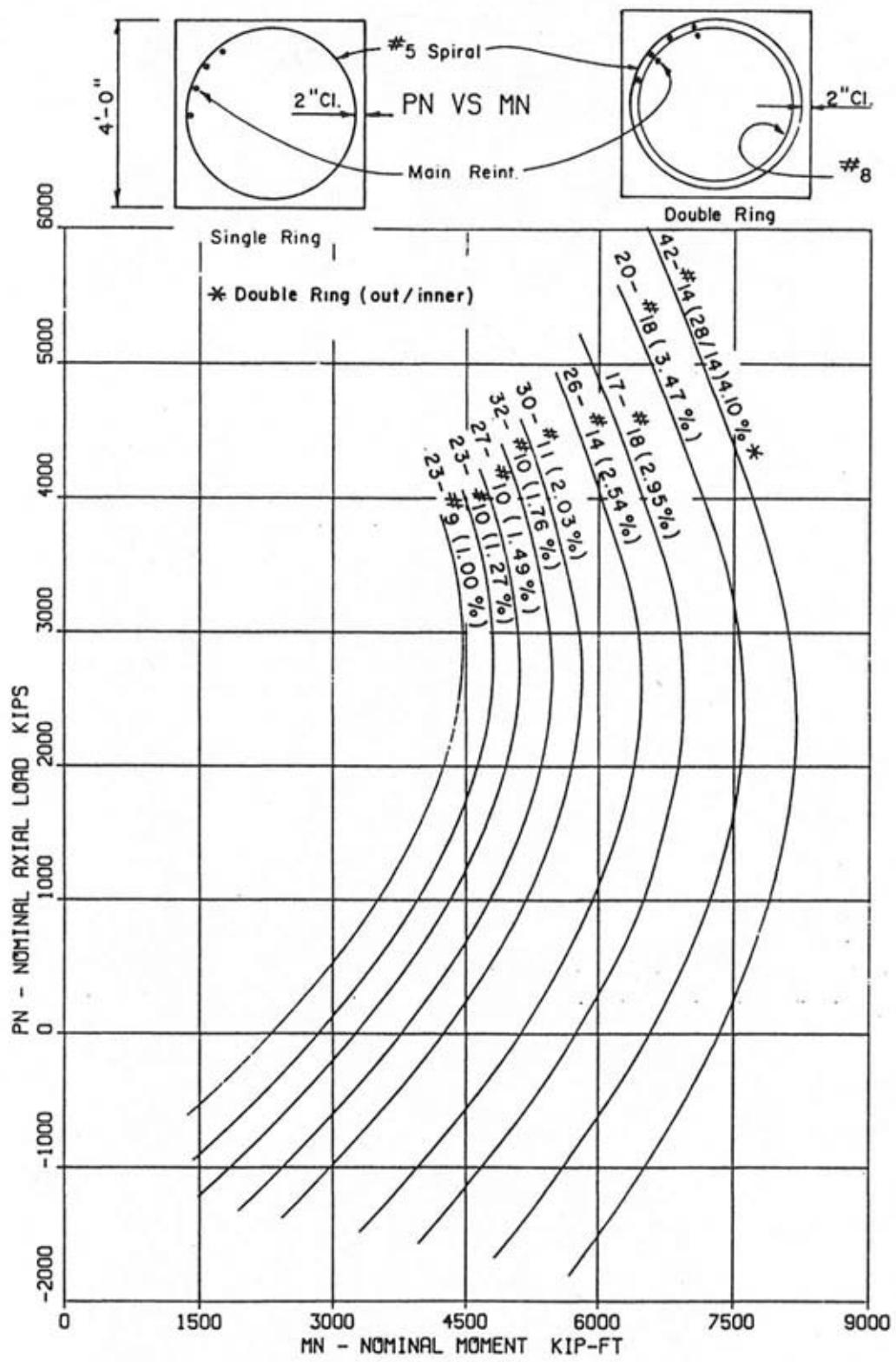


$$A = 36.8 \text{ ft}^2$$

$$I_x = 125.1 \text{ ft}^4$$

$$I_y = 93.8 \text{ ft}^4$$

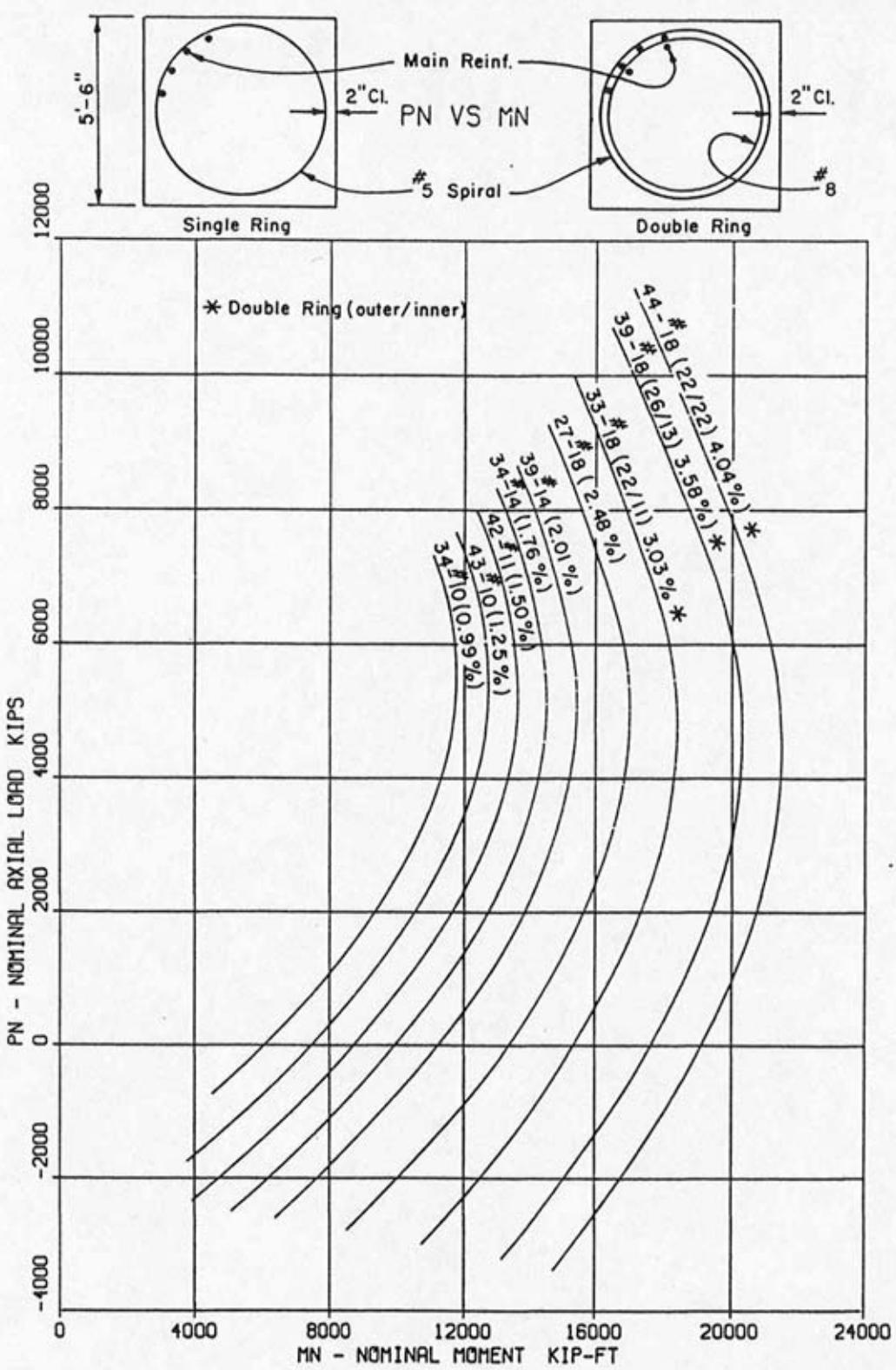
$$I_z = 218.8 \text{ ft}^4$$



$$A = 16.0 \text{ ft}^2$$

$$I = 21.3 \text{ ft}^4$$

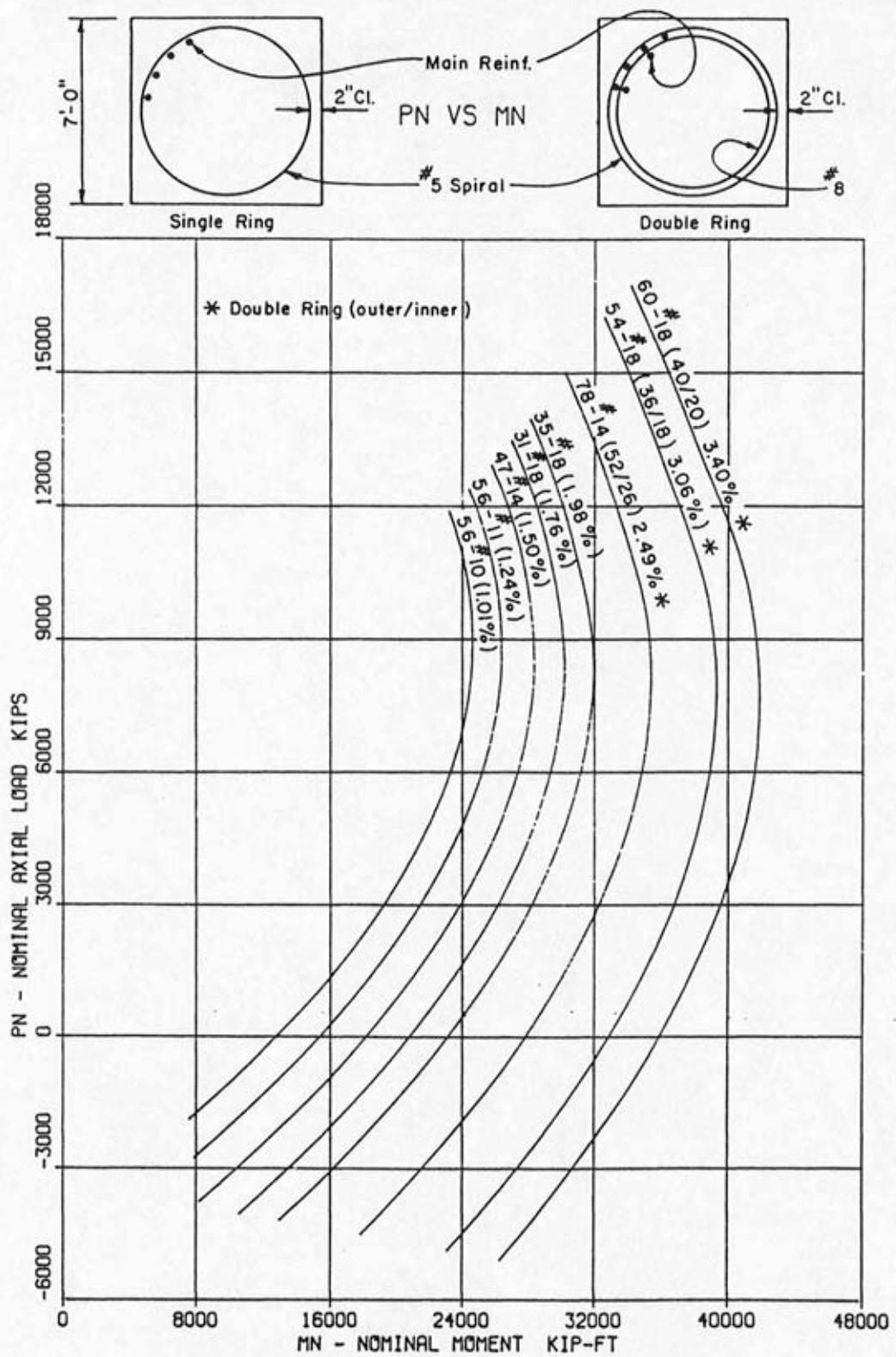
$$I_z = 42.7 \text{ ft}^4$$



$$A = 30.3 \text{ ft}^2$$

$$I = 76.3 \text{ ft}^4$$

$$I_z = 152.5 \text{ ft}^4$$



$$A = 49.0 \text{ ft}^2$$

$$I = 200.1 \text{ ft}^4$$

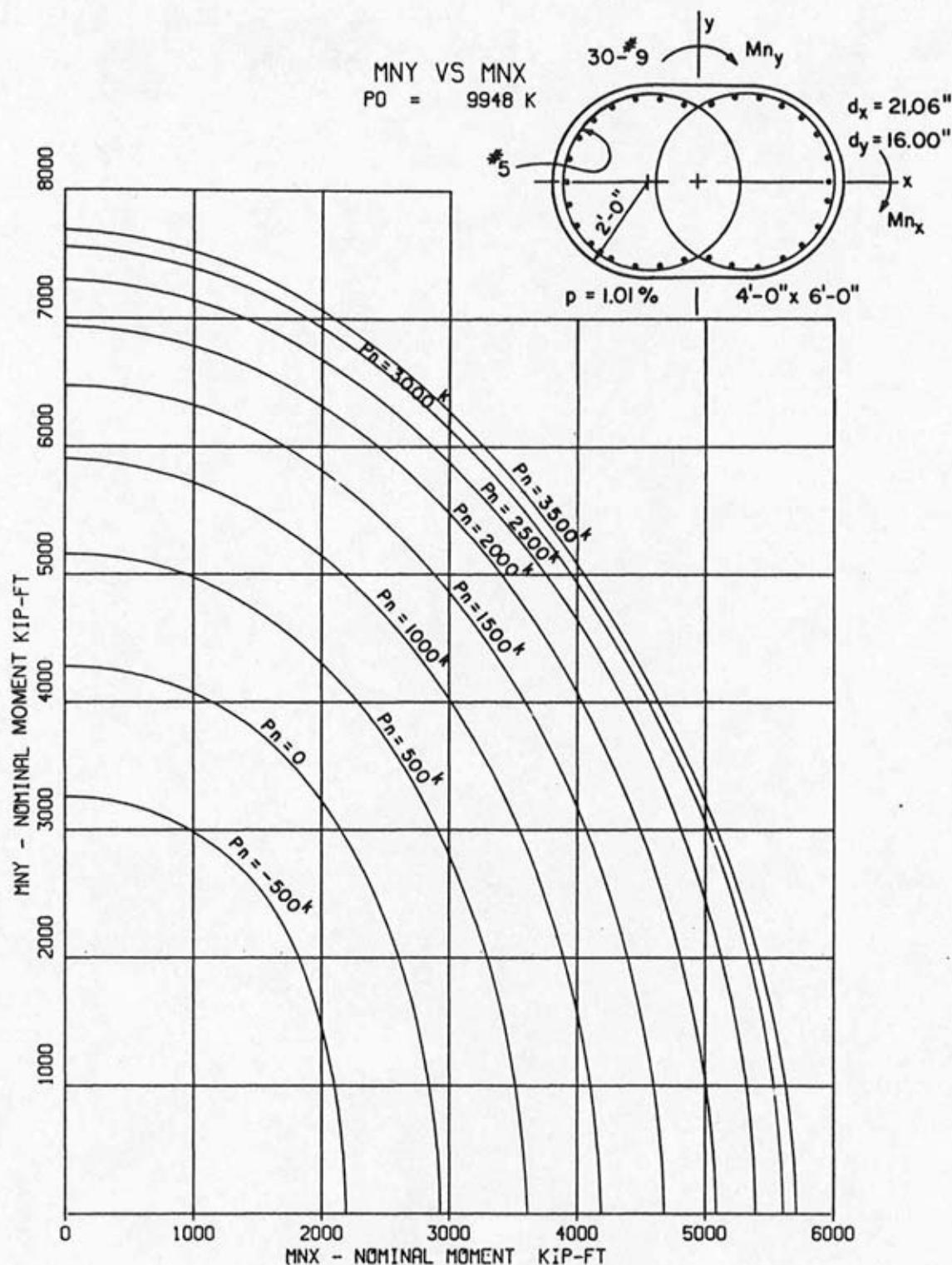
$$I_z = 400.2 \text{ ft}^4$$

Column Types

4'-0" × 6'-0"

5'-6" × 8'-3"

7'-10" × 10'-6"

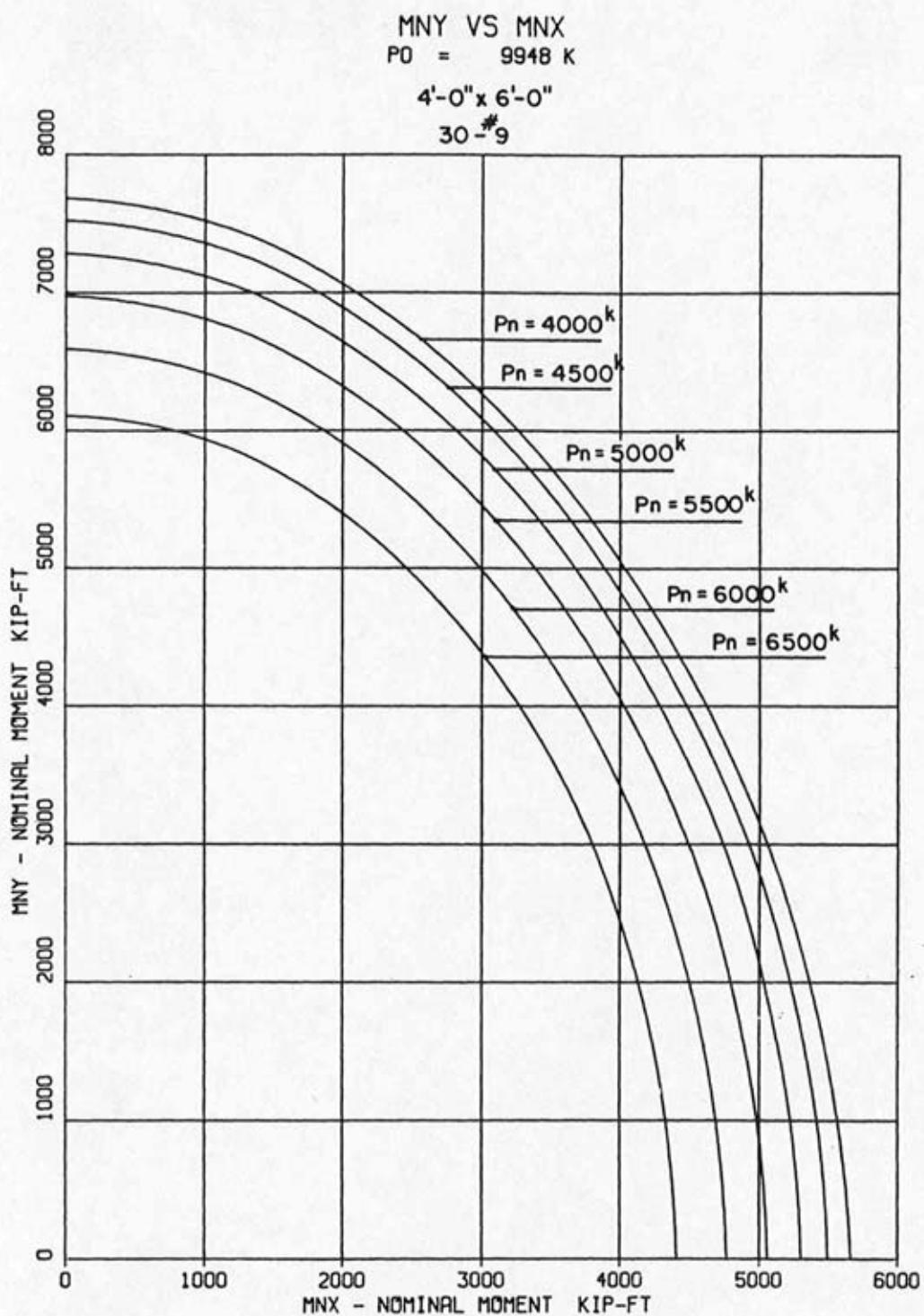


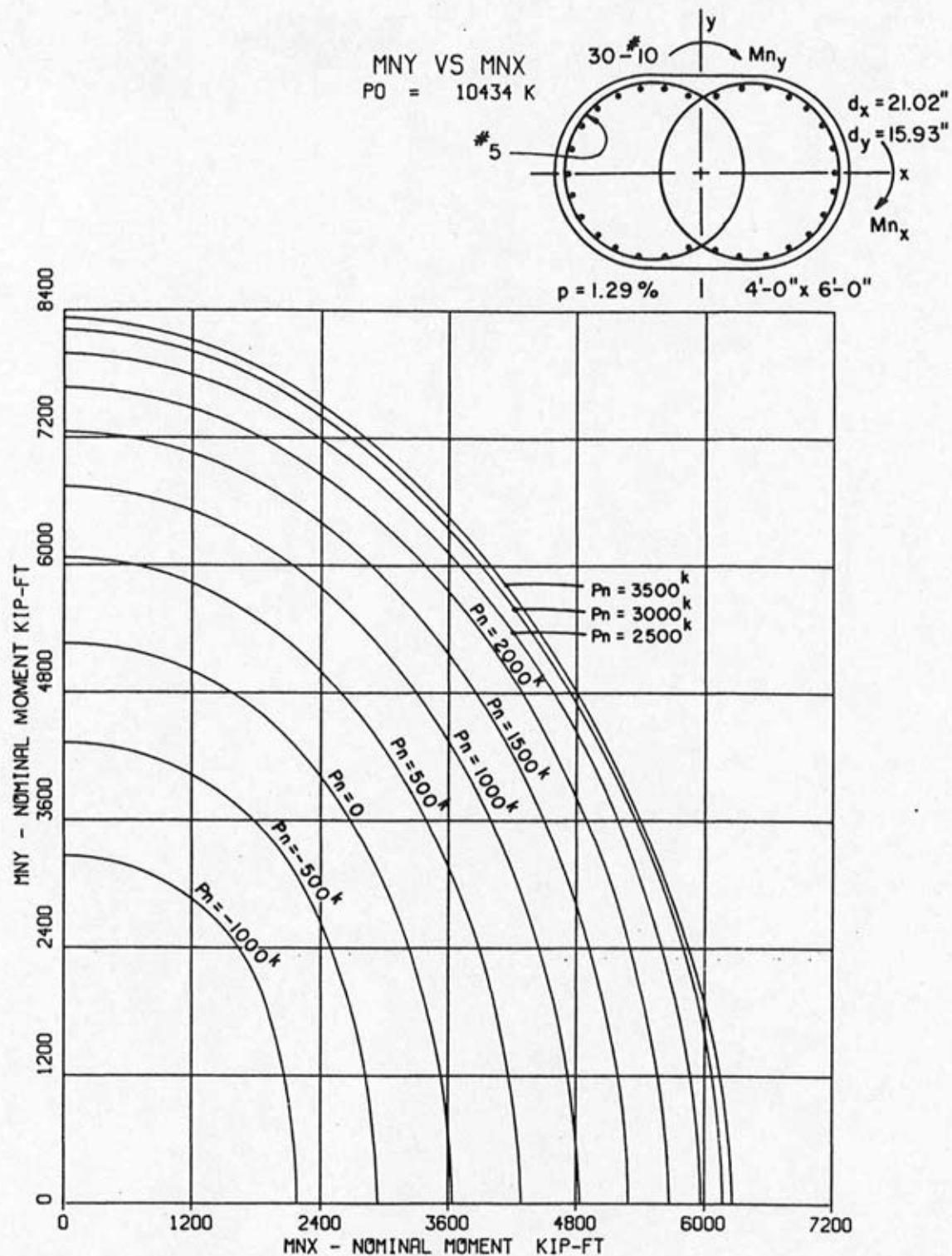
$$A = 20.6 \text{ ft}^2$$

$$I_x = 23.2 \text{ ft}^4$$

$$I_y = 49.1 \text{ ft}^4$$

$$I_z = 72.4 \text{ ft}^4$$





$$A = 20.6 \text{ ft}^2$$

$$I_x = 23.2 \text{ ft}^4$$

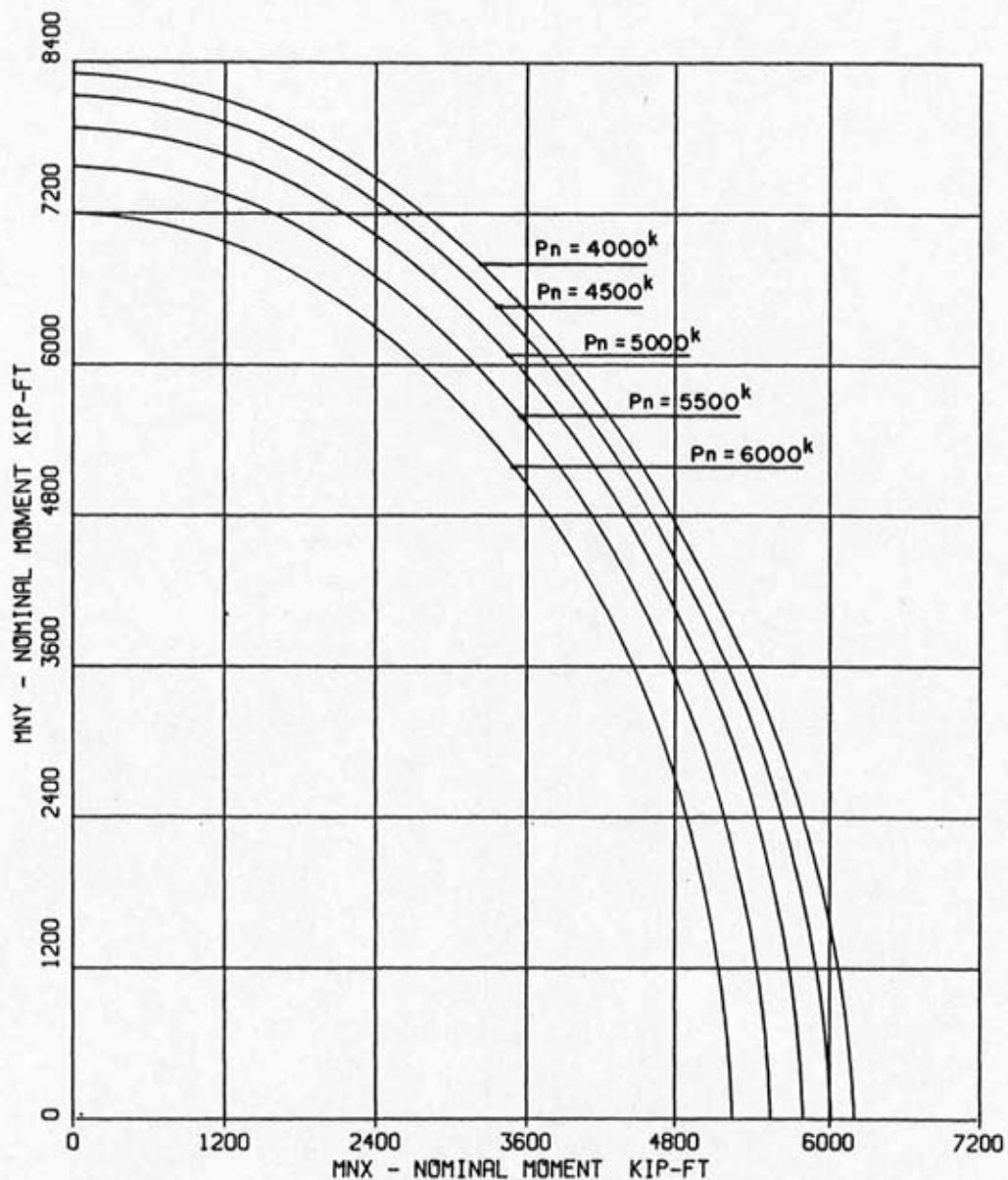
$$I_y = 49.1 \text{ ft}^4$$

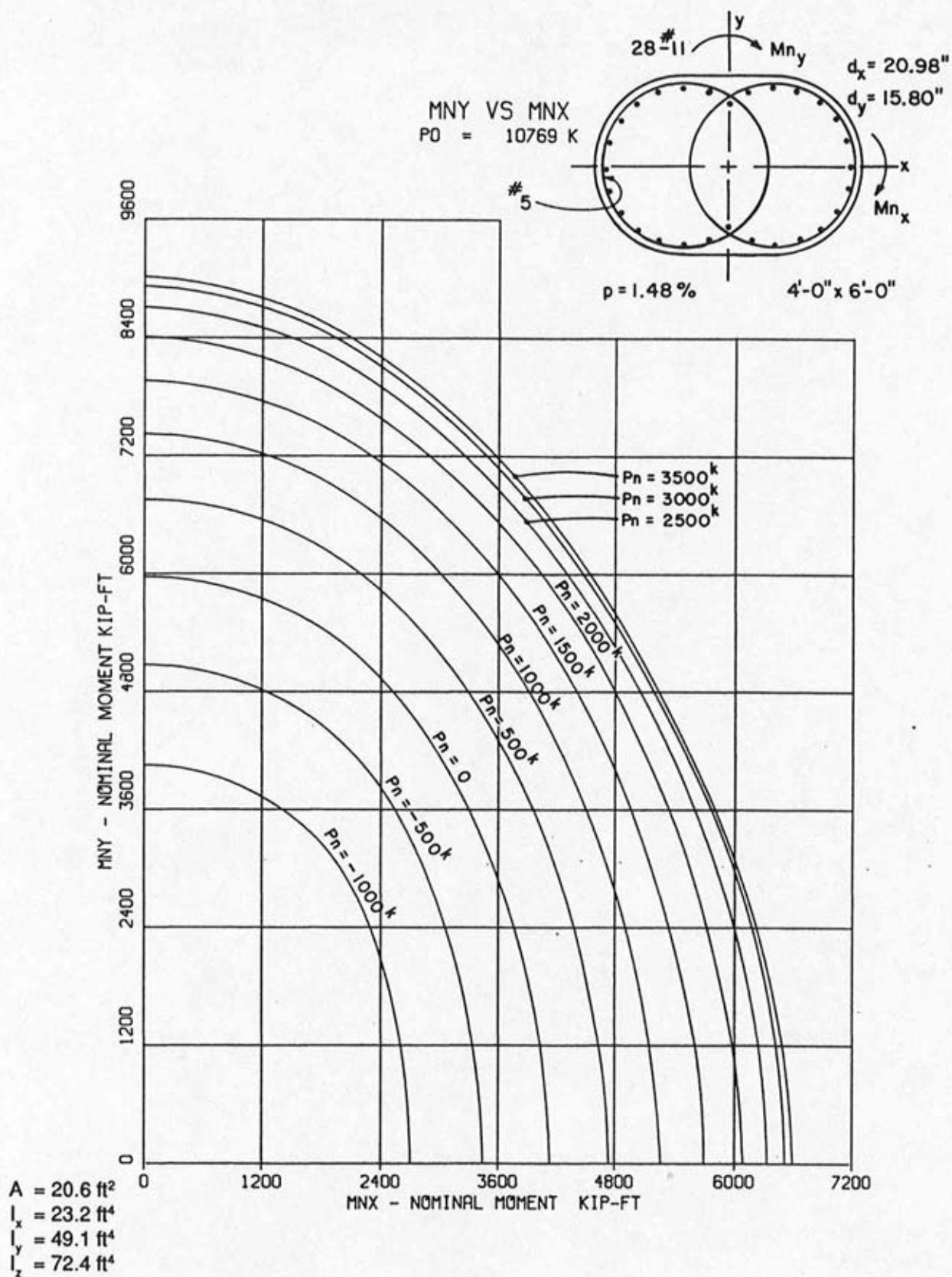
$$I_z = 72.4 \text{ ft}^4$$

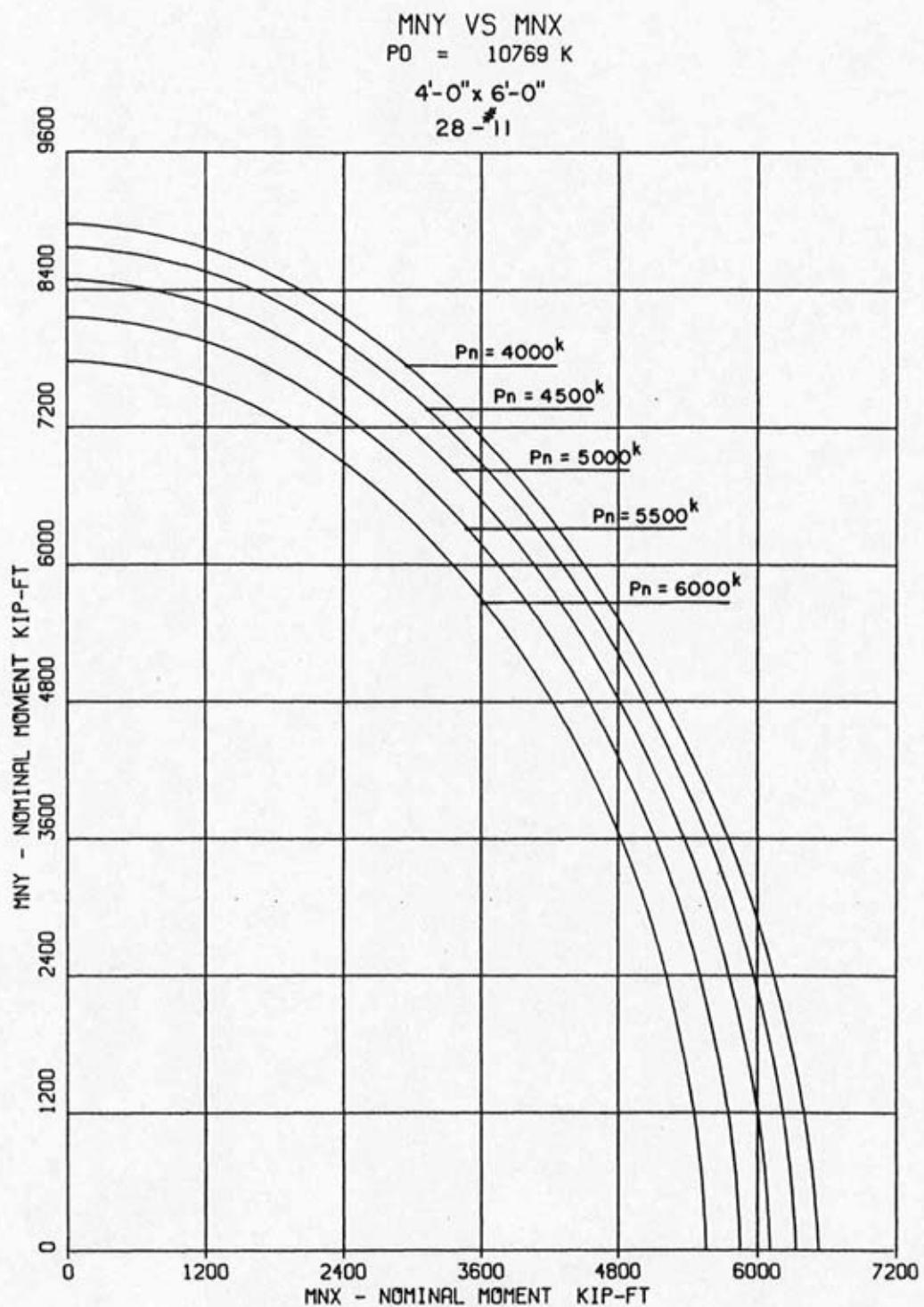
MNY VS MNX
 $P_0 = 10434 \text{ k}$

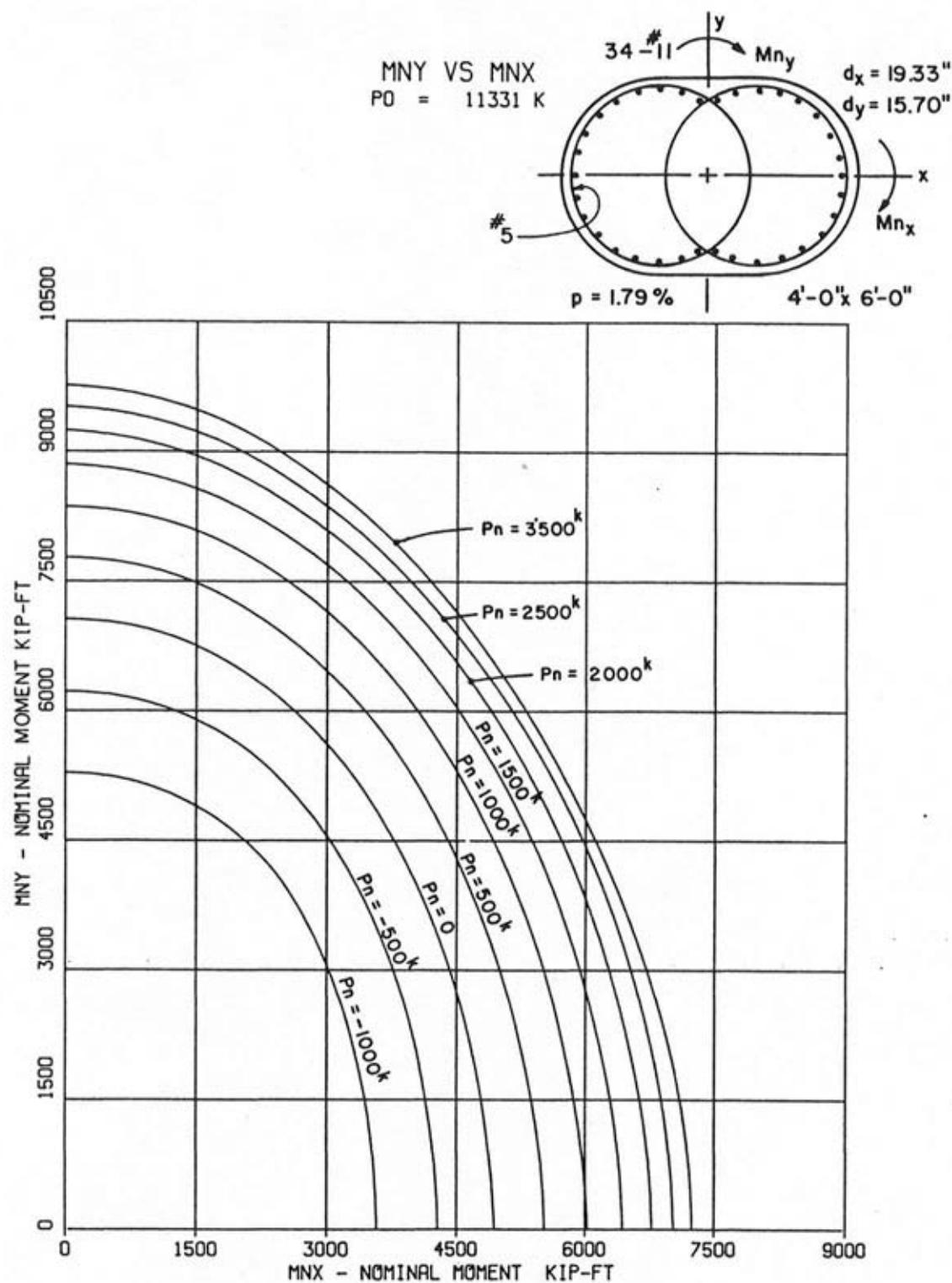
4'-0" x 6'-0"

30 - #









$$A = 20.6 \text{ ft}^2$$

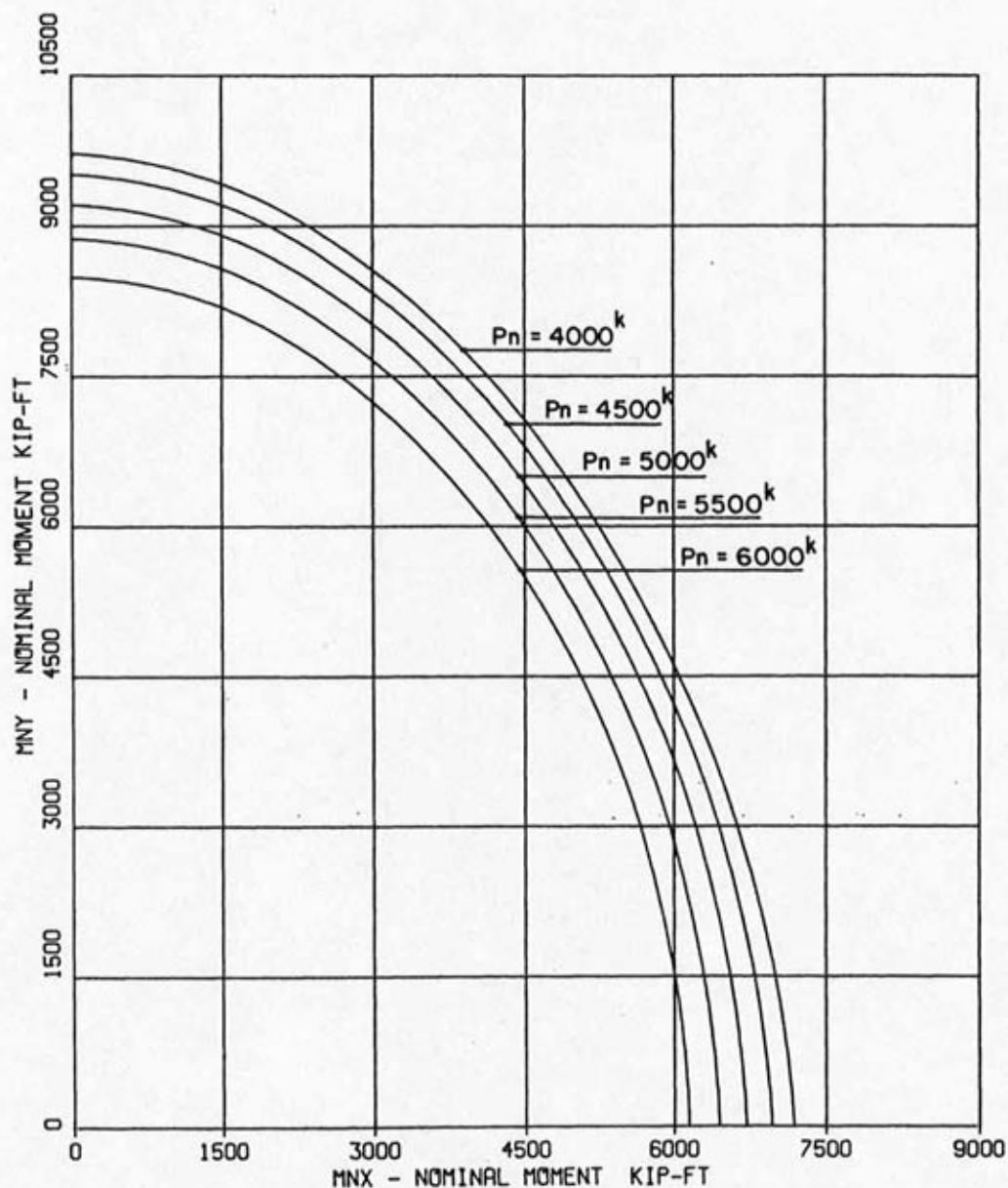
$$I_x = 23.2 \text{ ft}^4$$

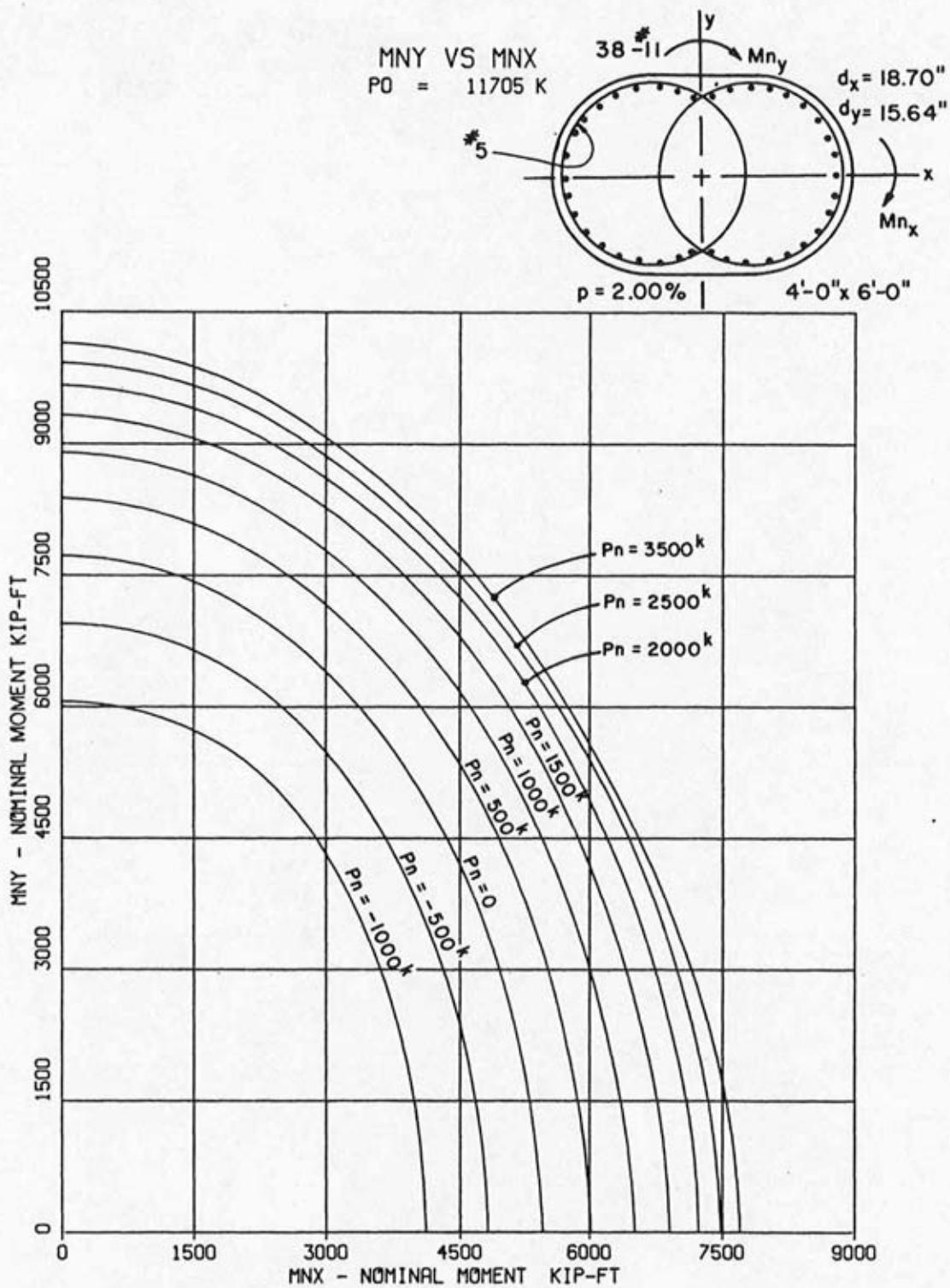
$$I_y = 49.1 \text{ ft}^4$$

$$I_z = 72.4 \text{ ft}^4$$

MNY VS MNX
 $P_0 = 11331 \text{ k}$

4'-0" x 6'-0"
34 - #11





$$A = 20.6 \text{ ft}^2$$

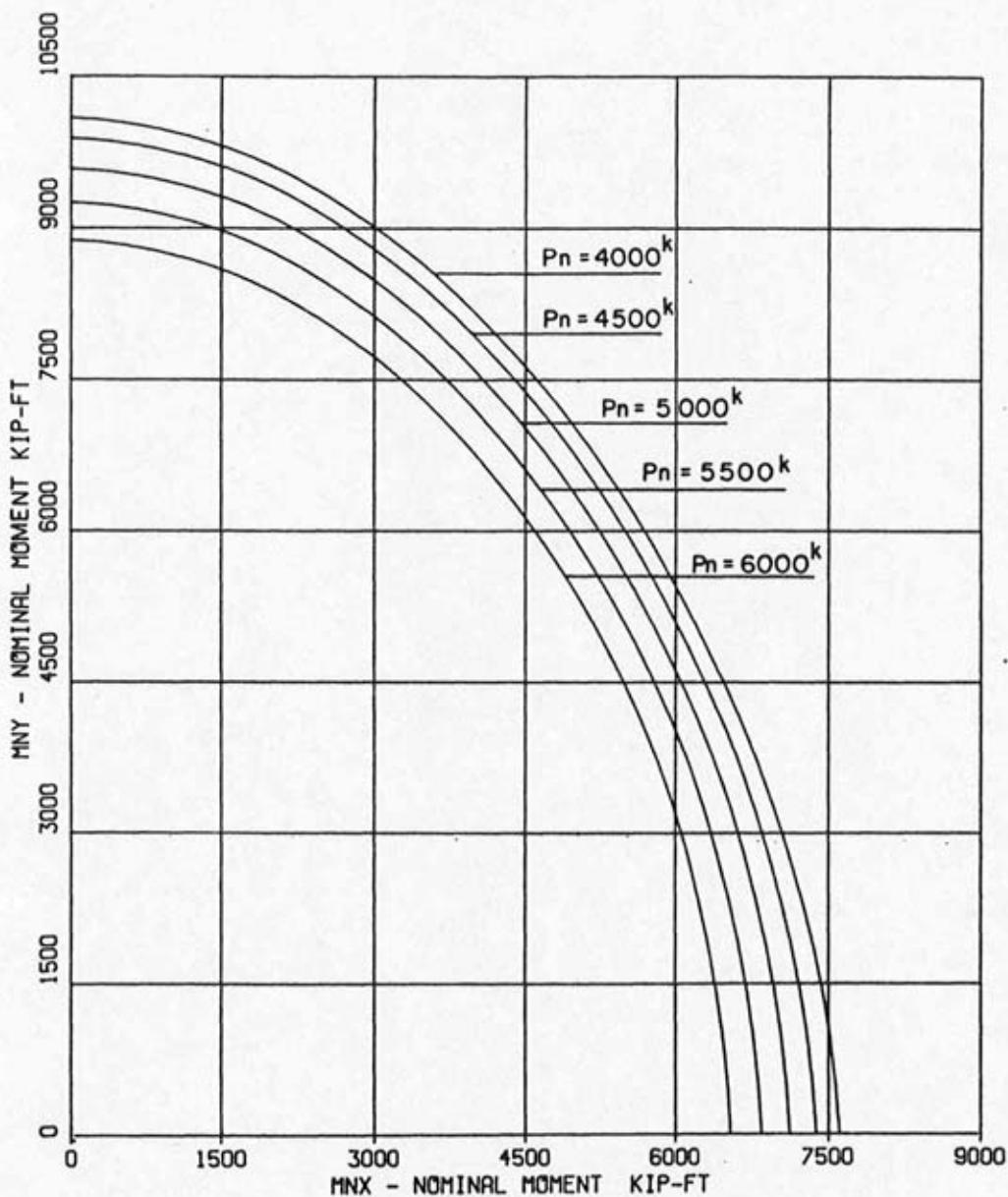
$$I_x = 23.2 \text{ ft}^4$$

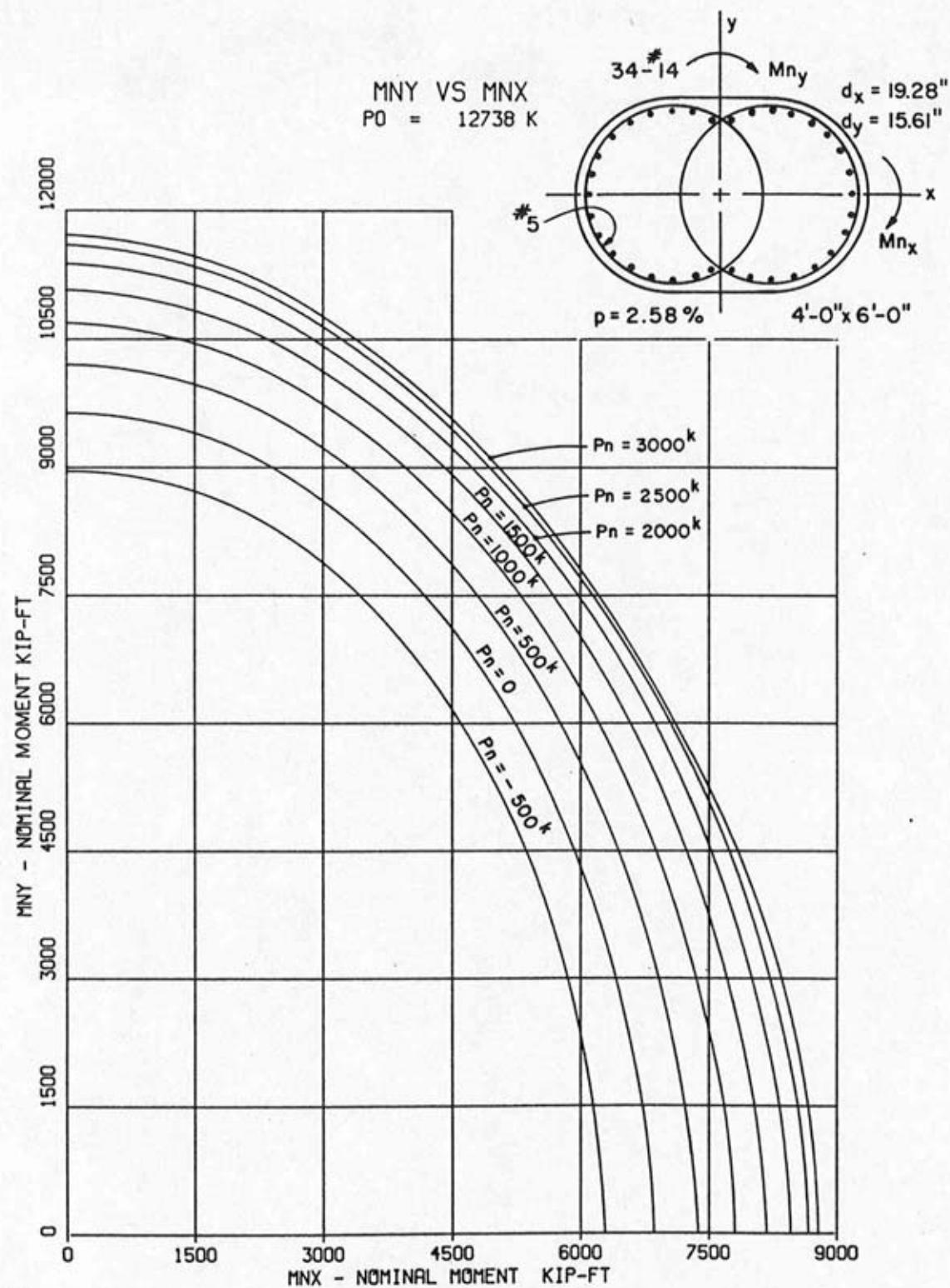
$$I_y = 49.1 \text{ ft}^4$$

$$I_z = 72.4 \text{ ft}^4$$

MNY VS MNX
 $P_0 = 11705 \text{ k}$

4'-0" x 6'-0"
38-#11



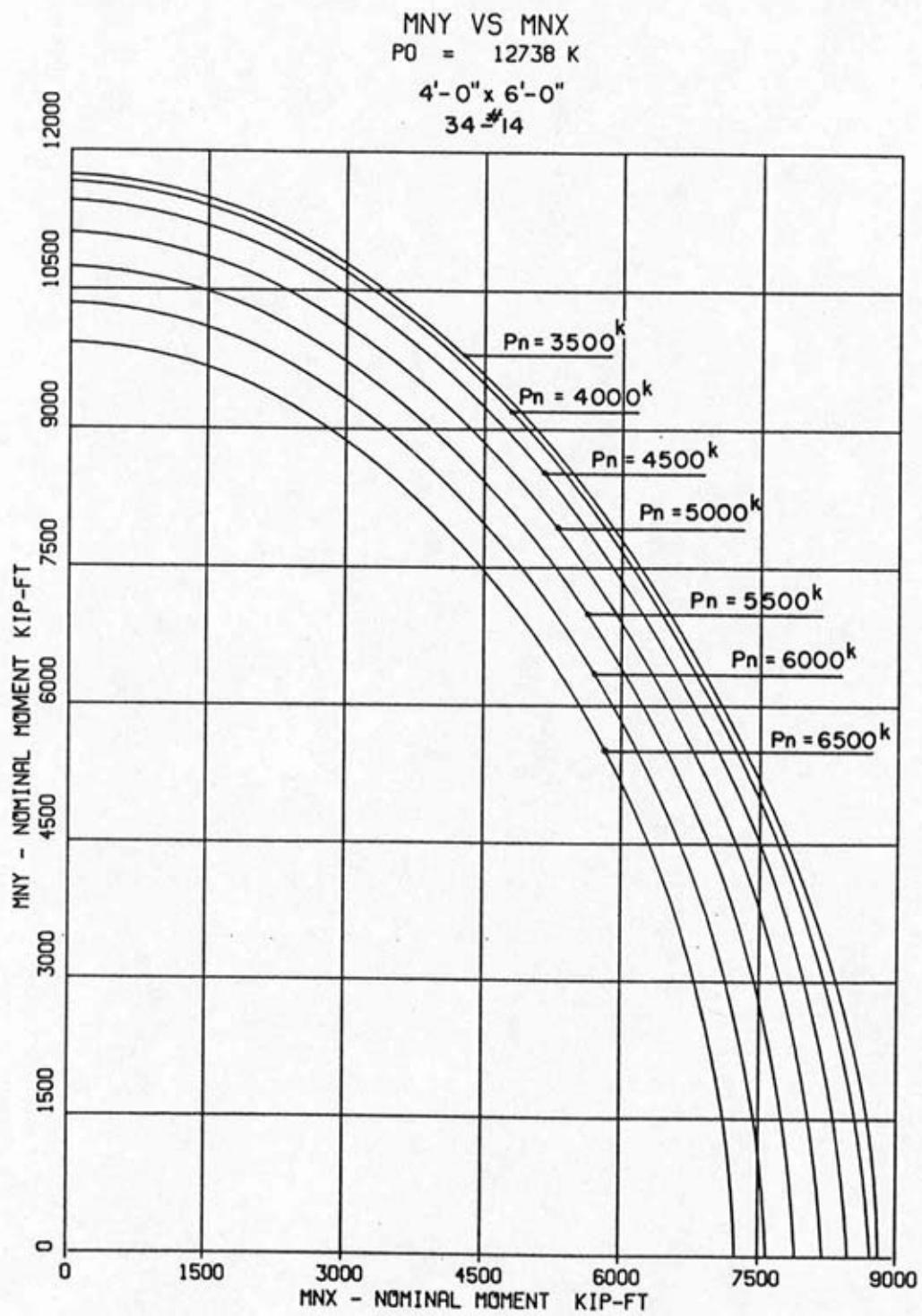


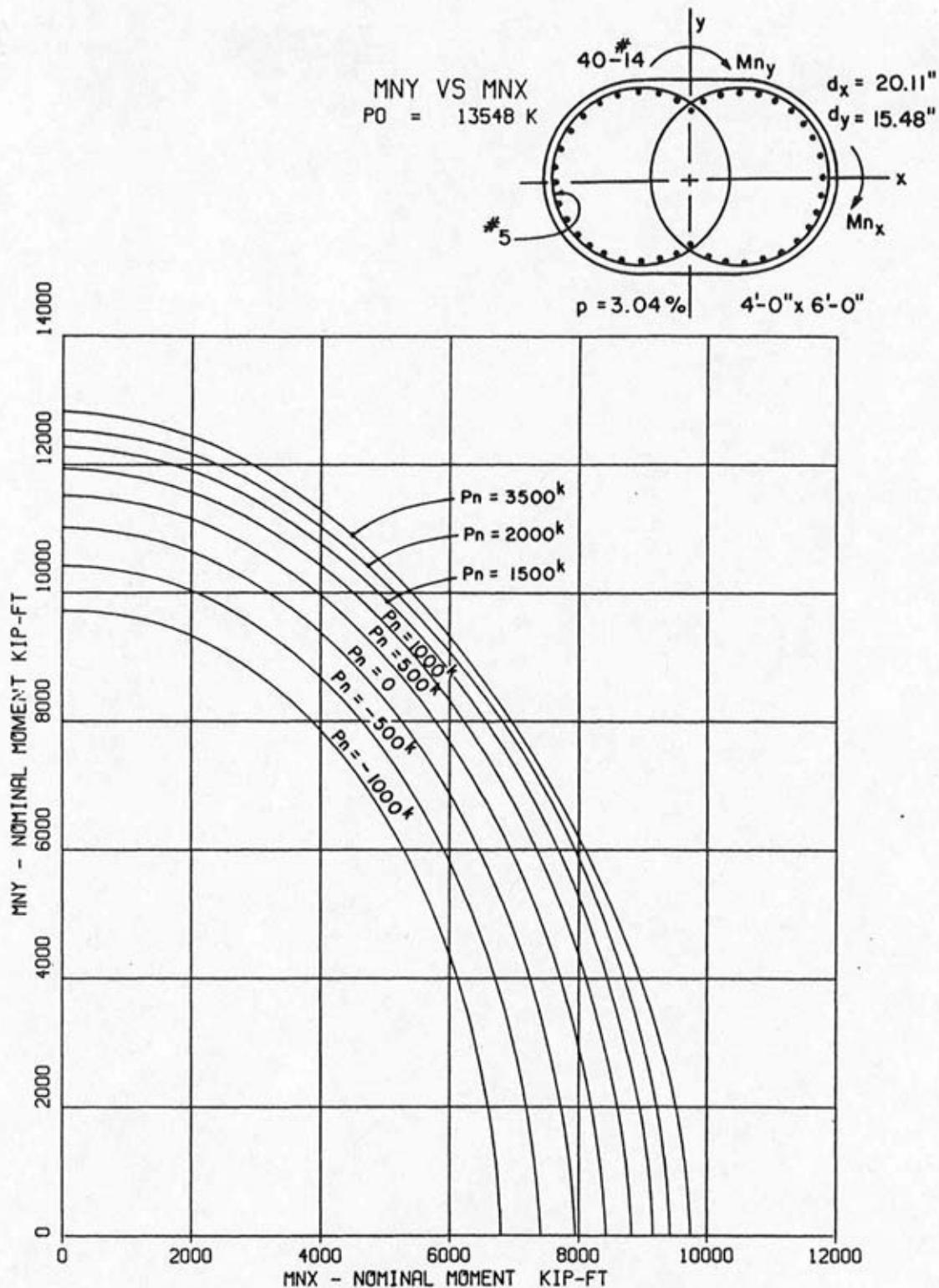
$$A = 20.6 \text{ ft}^2$$

$$I_x = 23.2 \text{ ft}^4$$

$$I_y = 49.1 \text{ ft}^4$$

$$I_z = 72.4 \text{ ft}^4$$



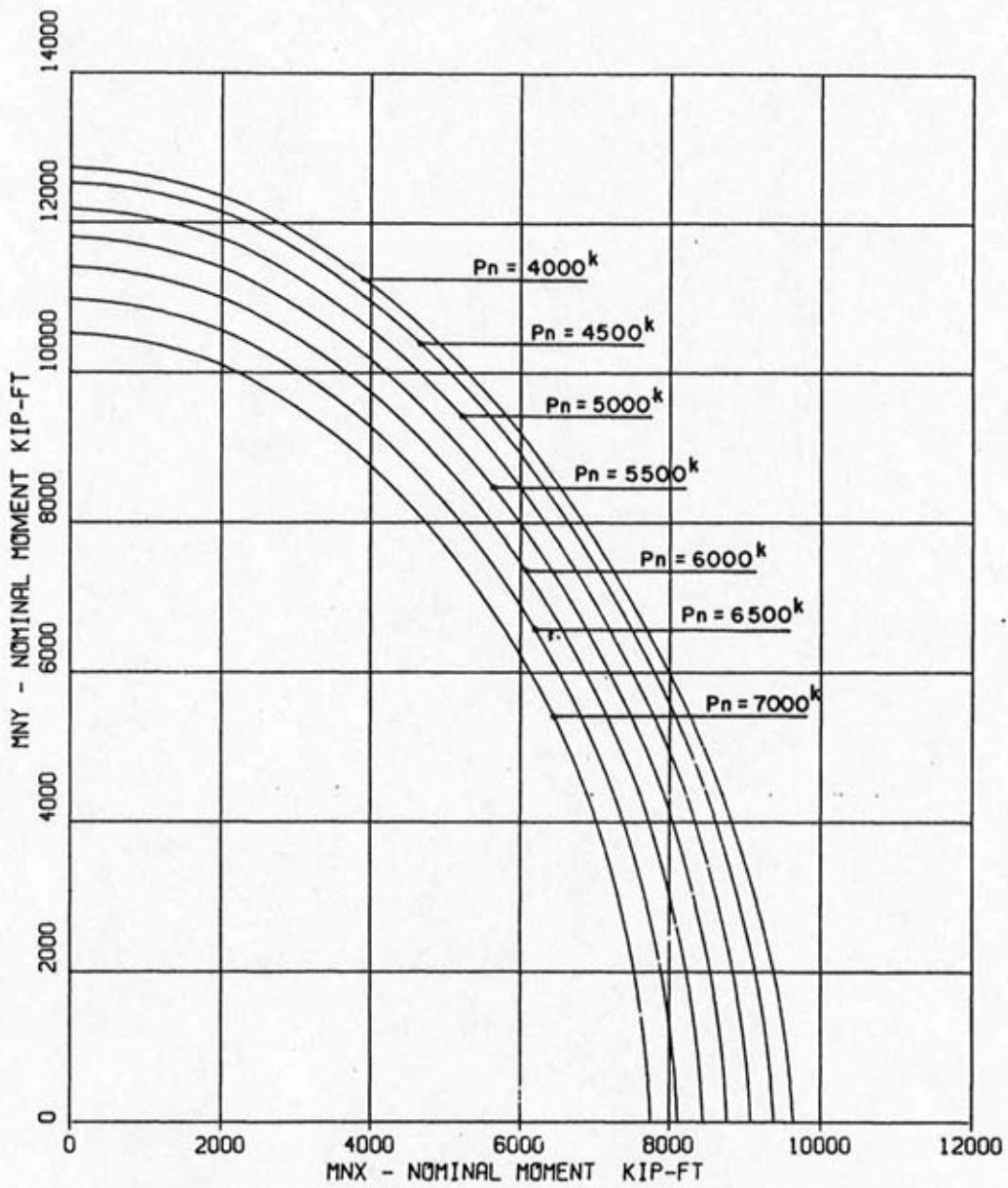


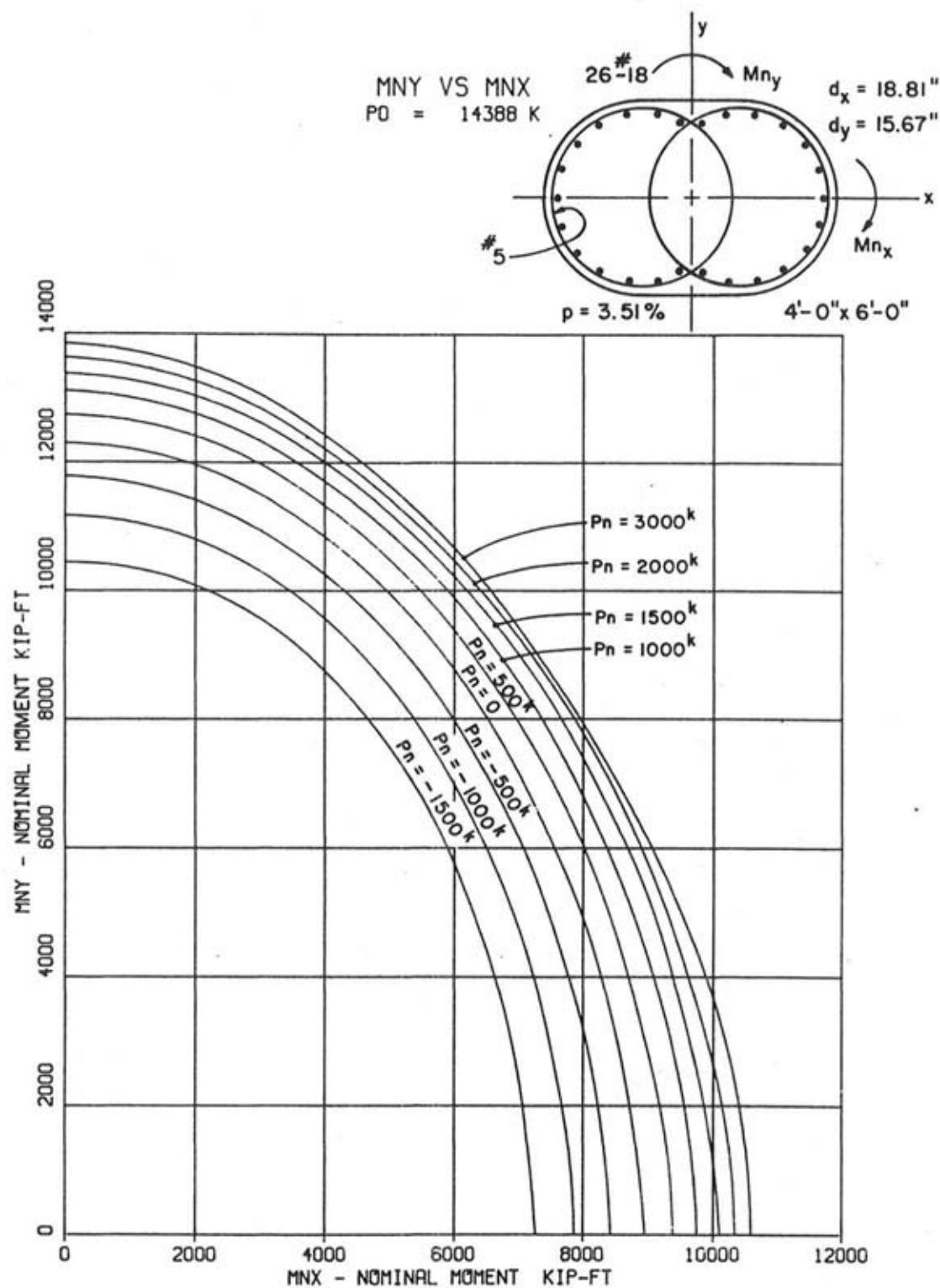
$$\begin{aligned} A &= 20.6 \text{ ft}^2 \\ I_x &= 23.2 \text{ ft}^4 \\ I_y &= 49.1 \text{ ft}^4 \\ I_z &= 72.4 \text{ ft}^4 \end{aligned}$$

MNY VS MNX
 $P_0 = 13548 \text{ K}$

4'-0" x 6'-0"

40-14





$$A = 20.6 \text{ ft}^2$$

$$I_x = 23.2 \text{ ft}^4$$

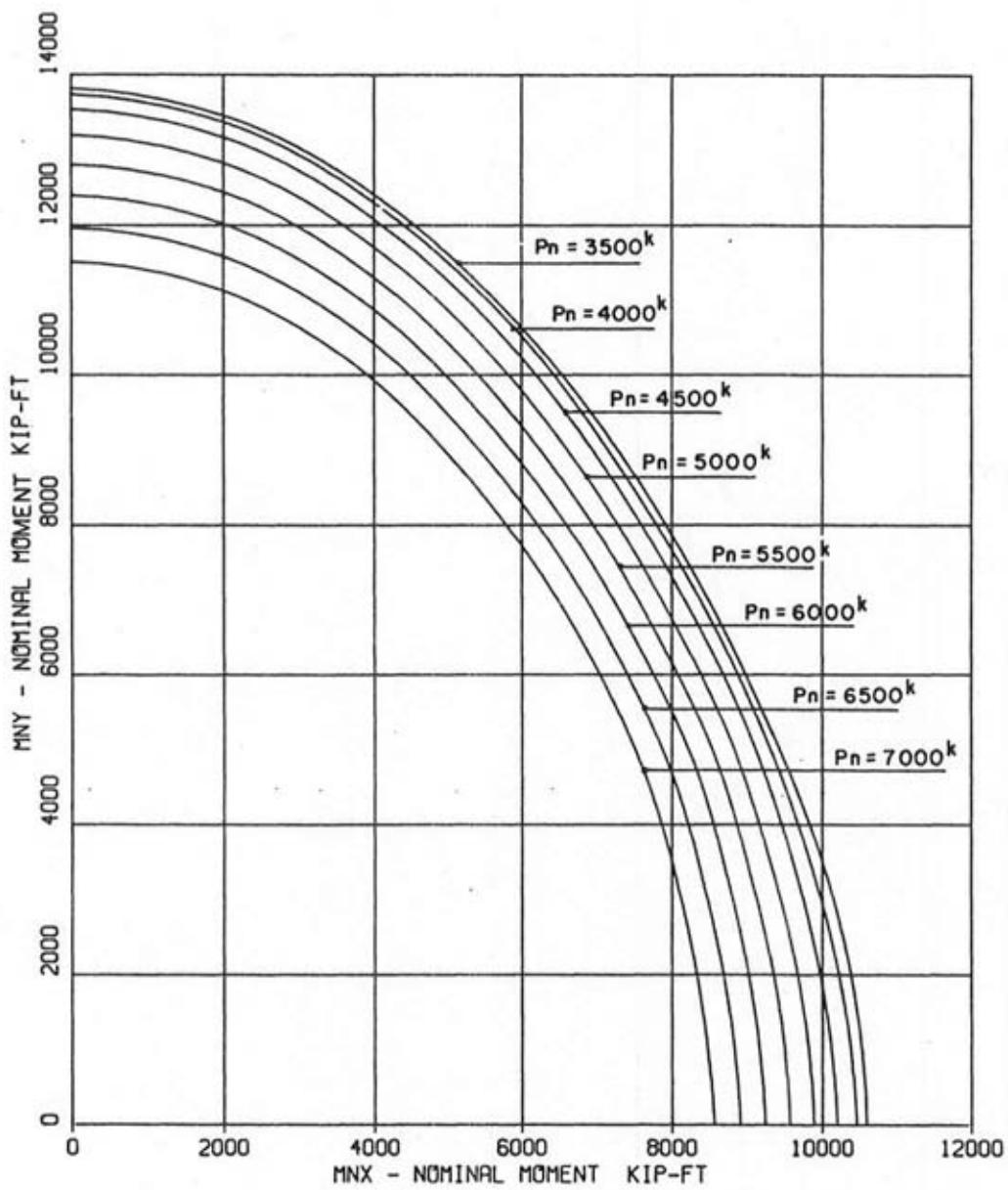
$$I_y = 49.1 \text{ ft}^4$$

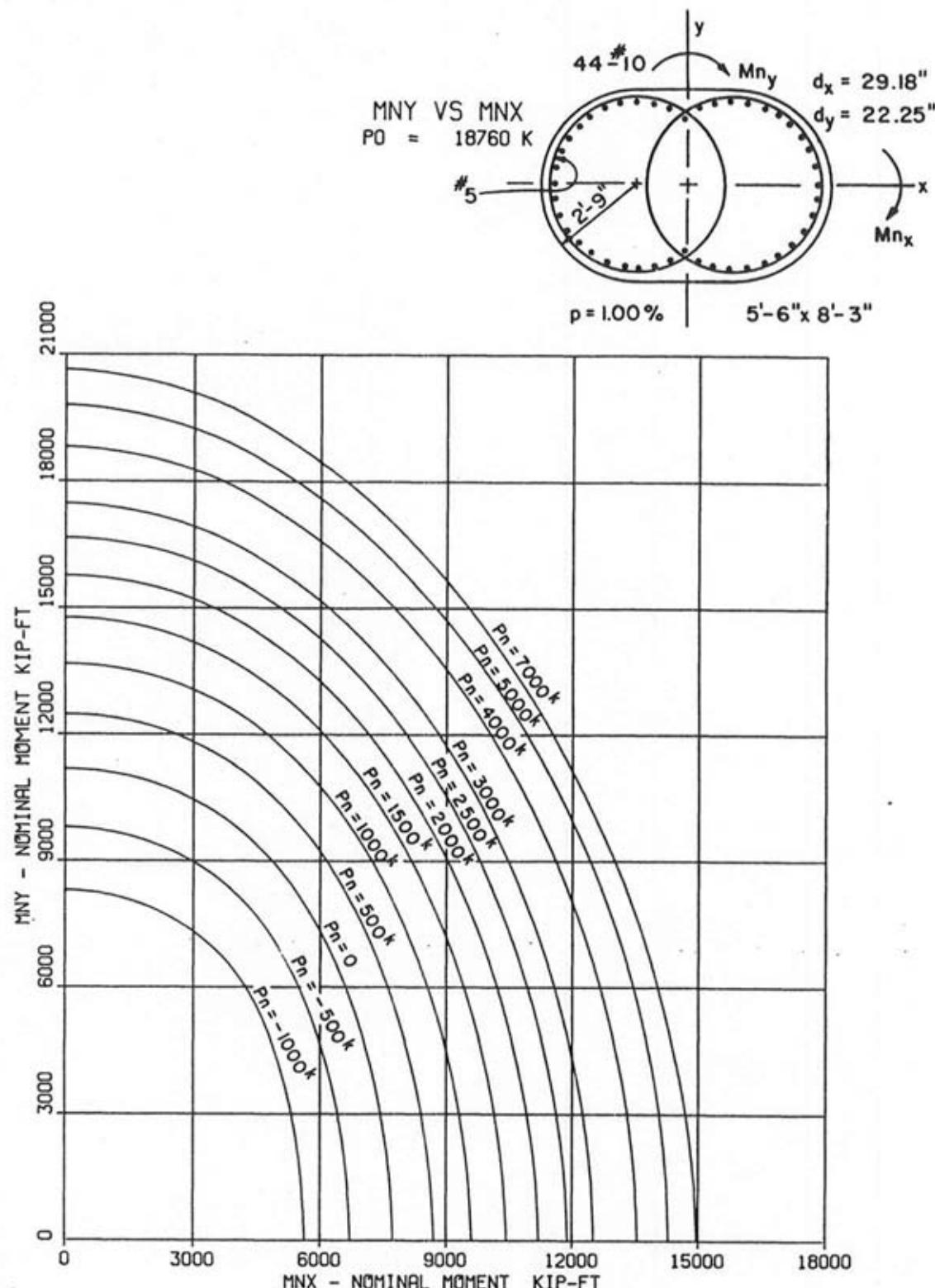
$$I_z = 72.4 \text{ ft}^4$$

MNY VS MNX
PO = 14388 K

4'-0" x 6'-0"

26-18





$$A = 38.9 \text{ ft}^2$$

$$I_x = 83.1 \text{ ft}^4$$

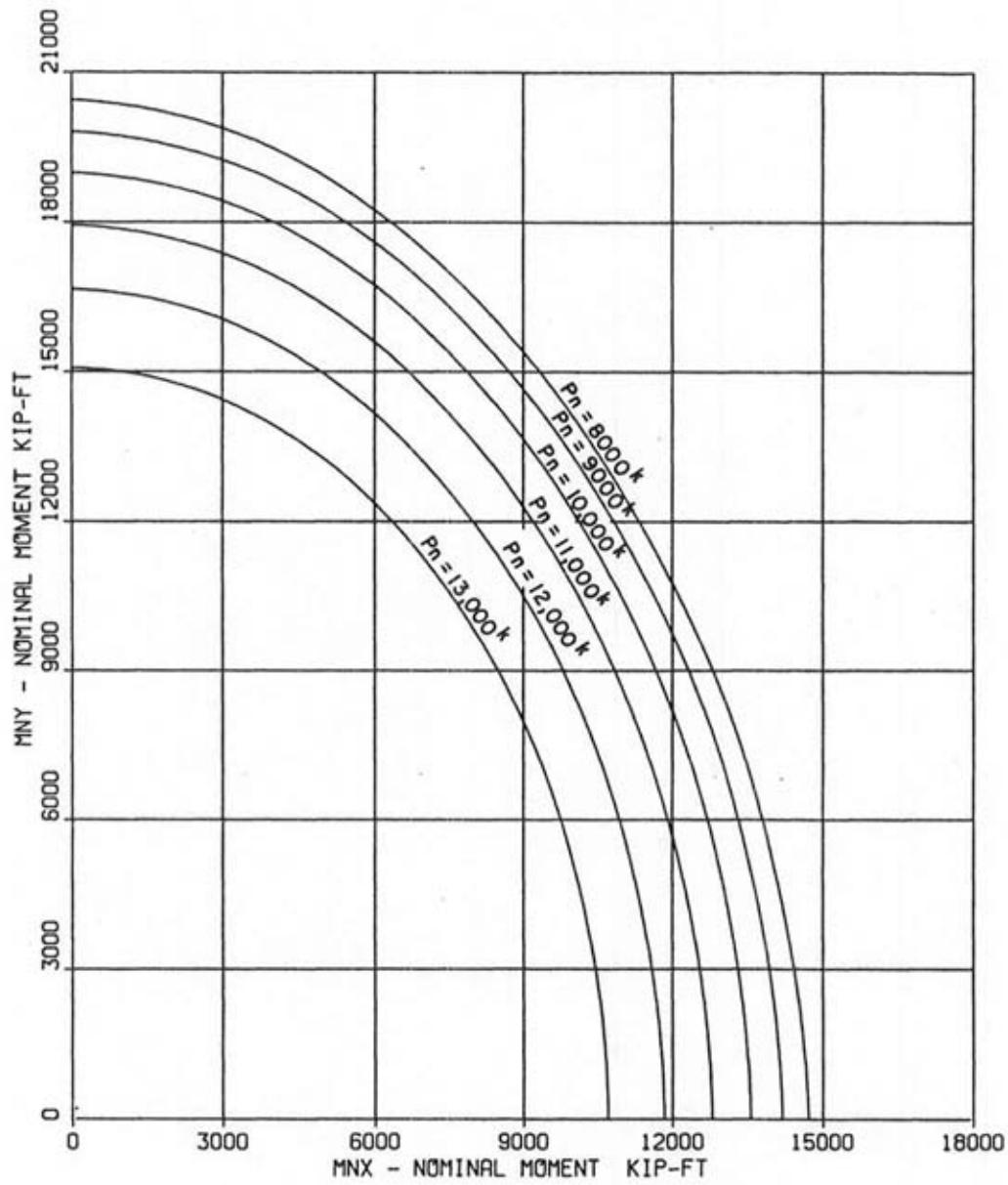
$$I_y = 175.6 \text{ ft}^4$$

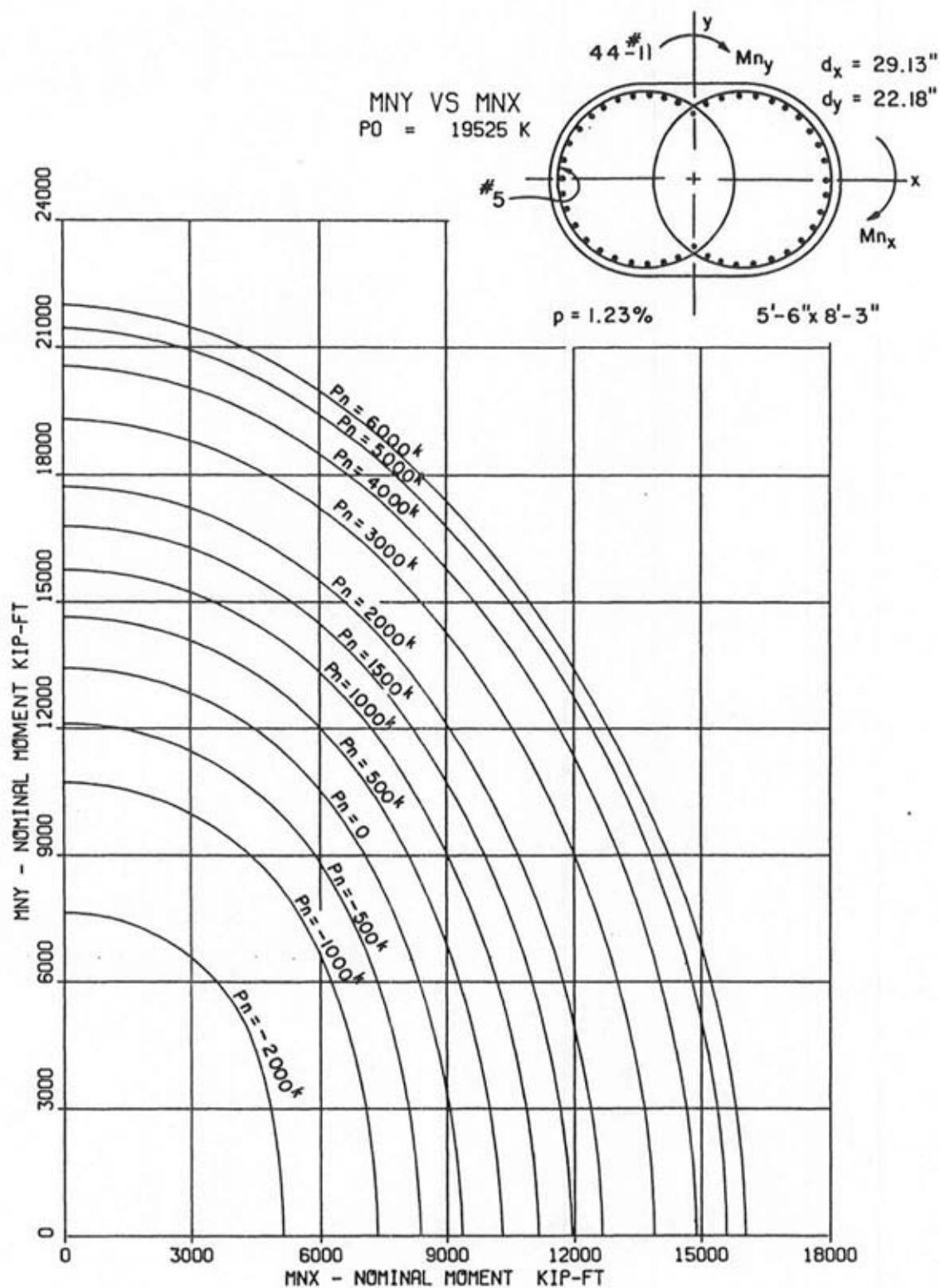
$$I_z = 258.7 \text{ ft}^4$$

MNY VS MNX
 $P_0 = 18760 \text{ K}$

5'-6" x 8'-3"

44-#10



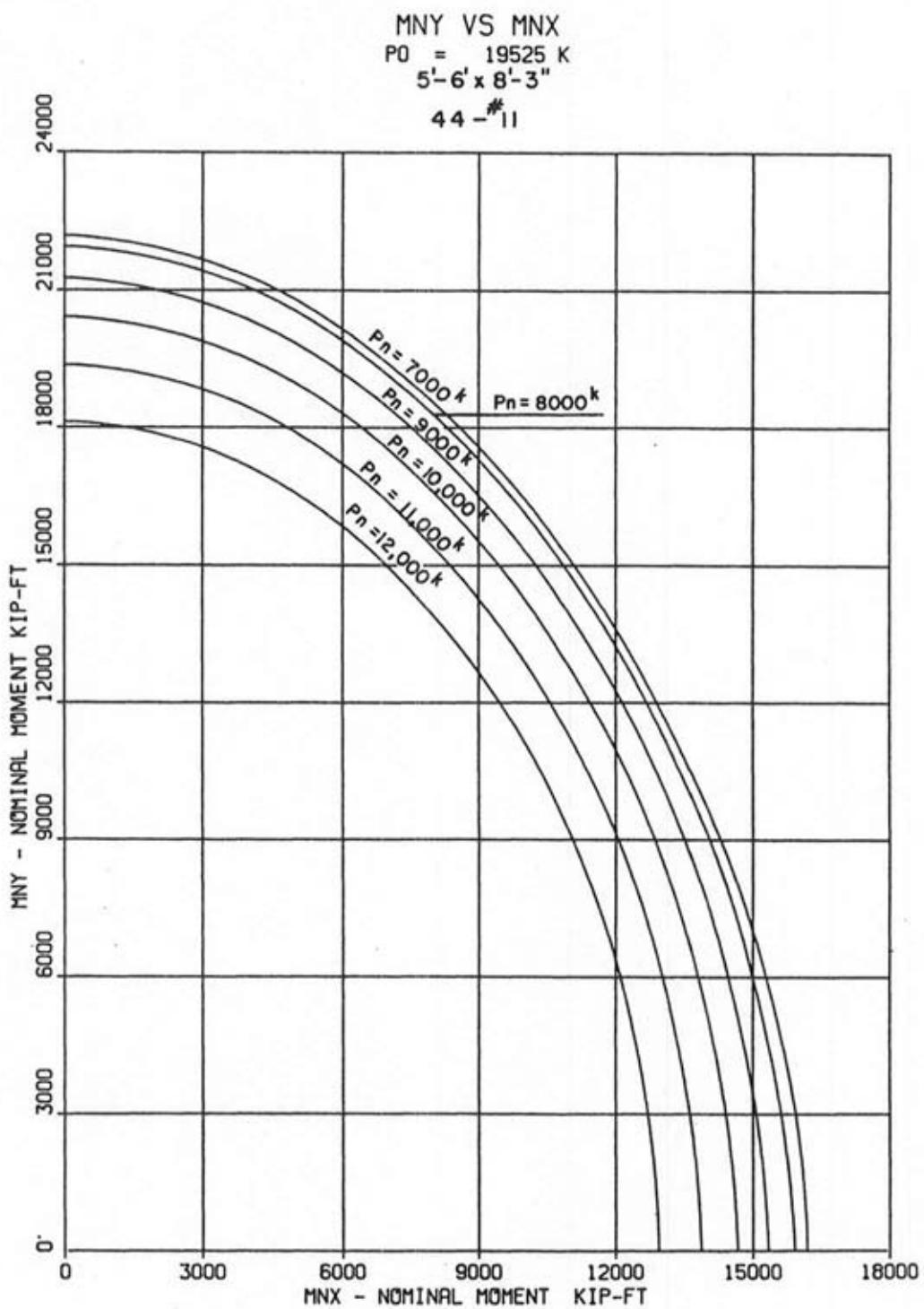


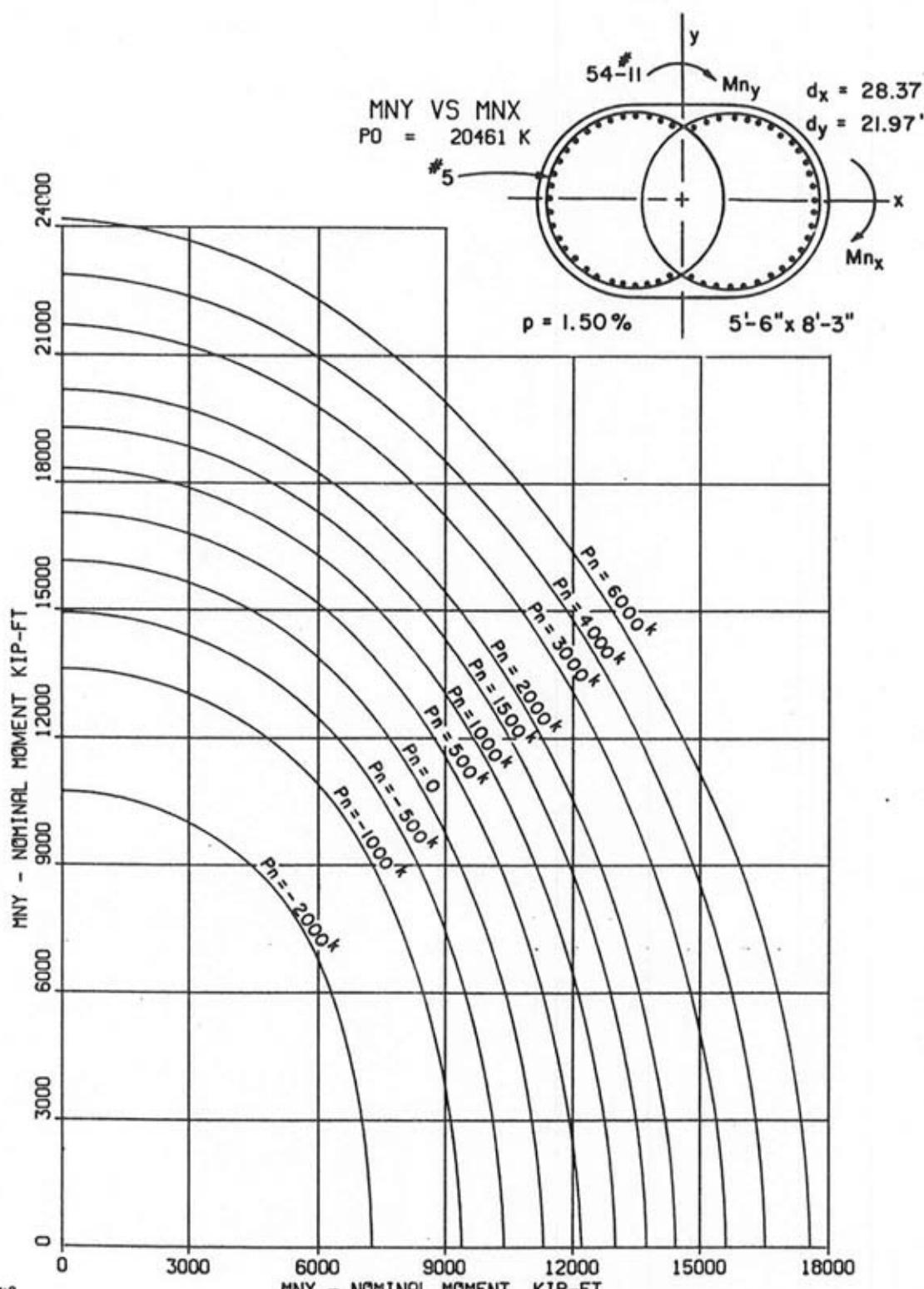
$$A = 38.9 \text{ ft}^2$$

$$I_x = 83.1 \text{ ft}^4$$

$$I_y = 175.6 \text{ ft}^4$$

$$I_z = 258.7 \text{ ft}^4$$



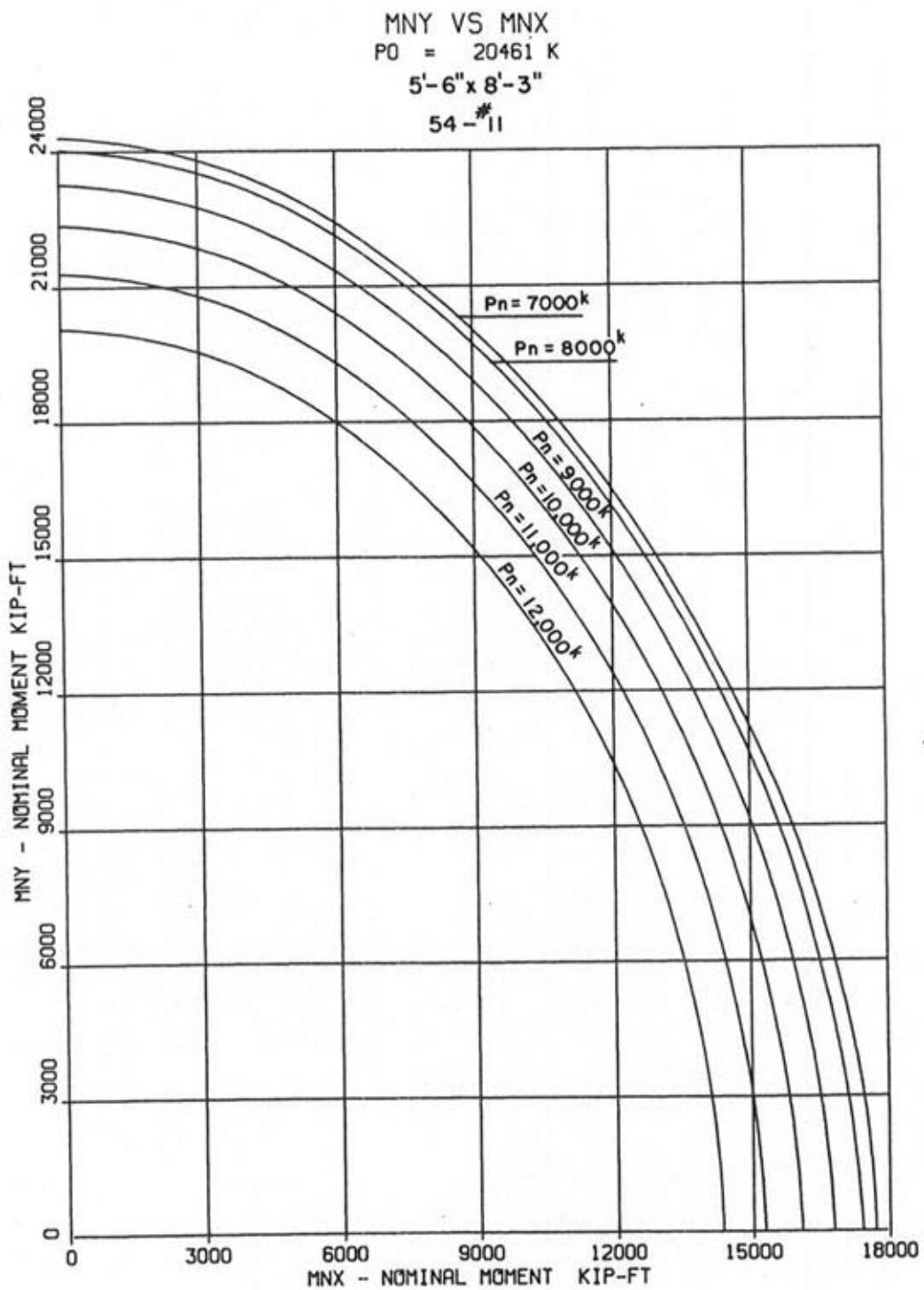


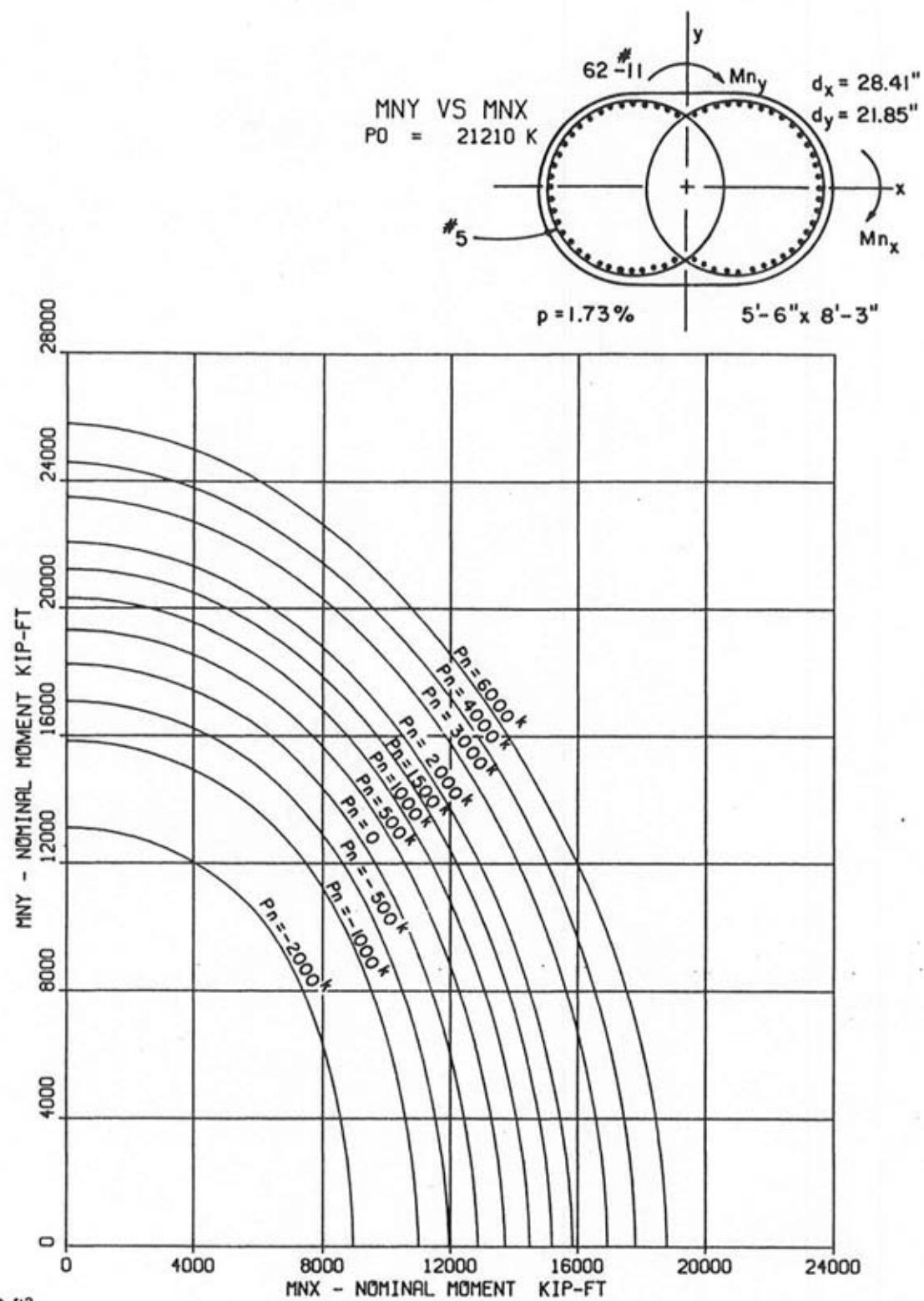
$$A = 38.9 \text{ ft}^2$$

$$I_x = 83.1 \text{ ft}^4$$

$$I_y = 175.6 \text{ ft}^4$$

$$I_z = 258.7 \text{ ft}^4$$





$$A = 38.9 \text{ ft}^2$$

$$I_x = 83.1 \text{ ft}^4$$

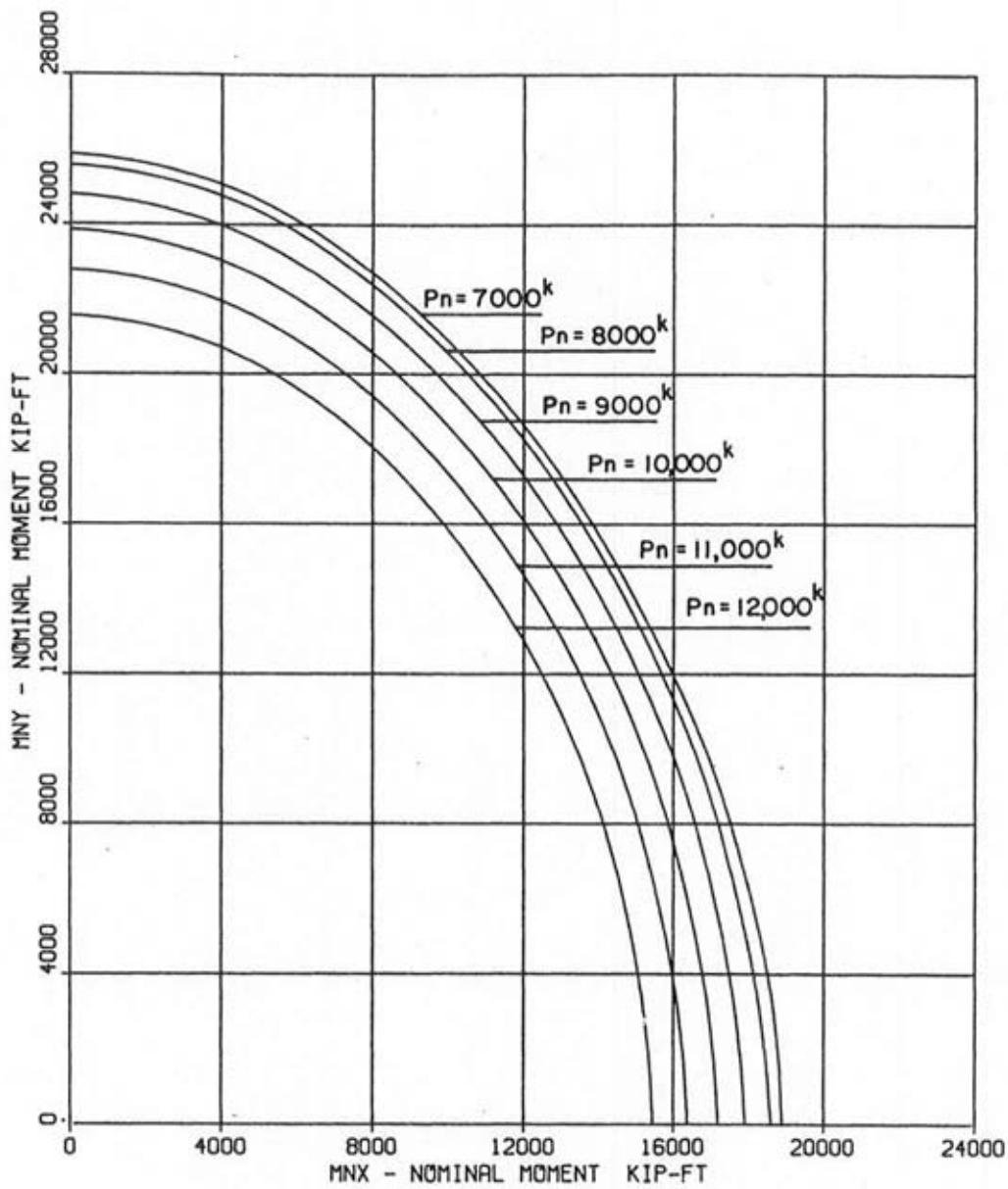
$$I_y = 175.6 \text{ ft}^4$$

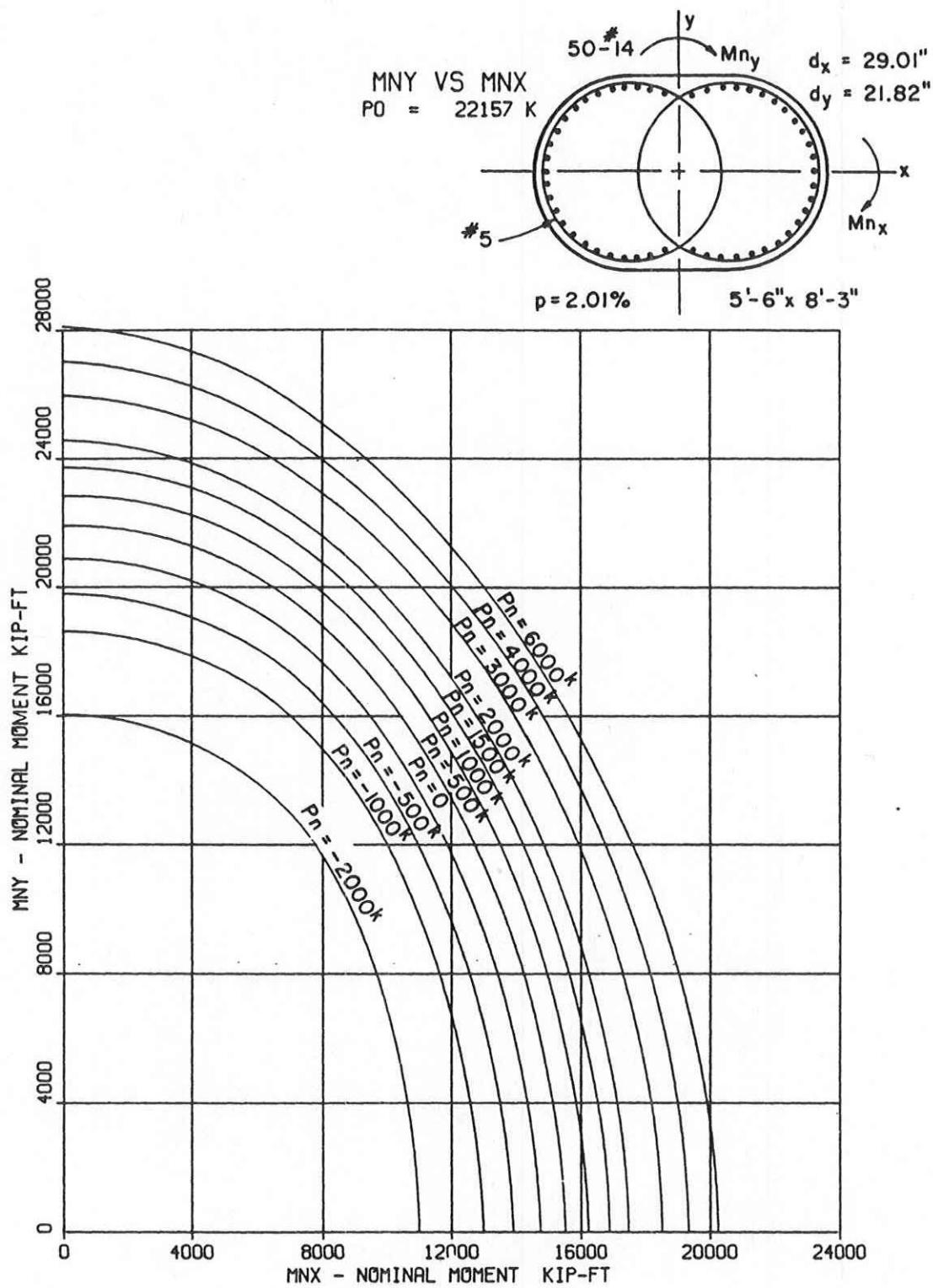
$$I_z = 258.7 \text{ ft}^4$$

MNY VS MNX
PO = 21210 K

5'-6"x 8'-3"

62 - #11





$$A = 38.9 \text{ ft}^2$$

$$I_x = 83.1 \text{ ft}^4$$

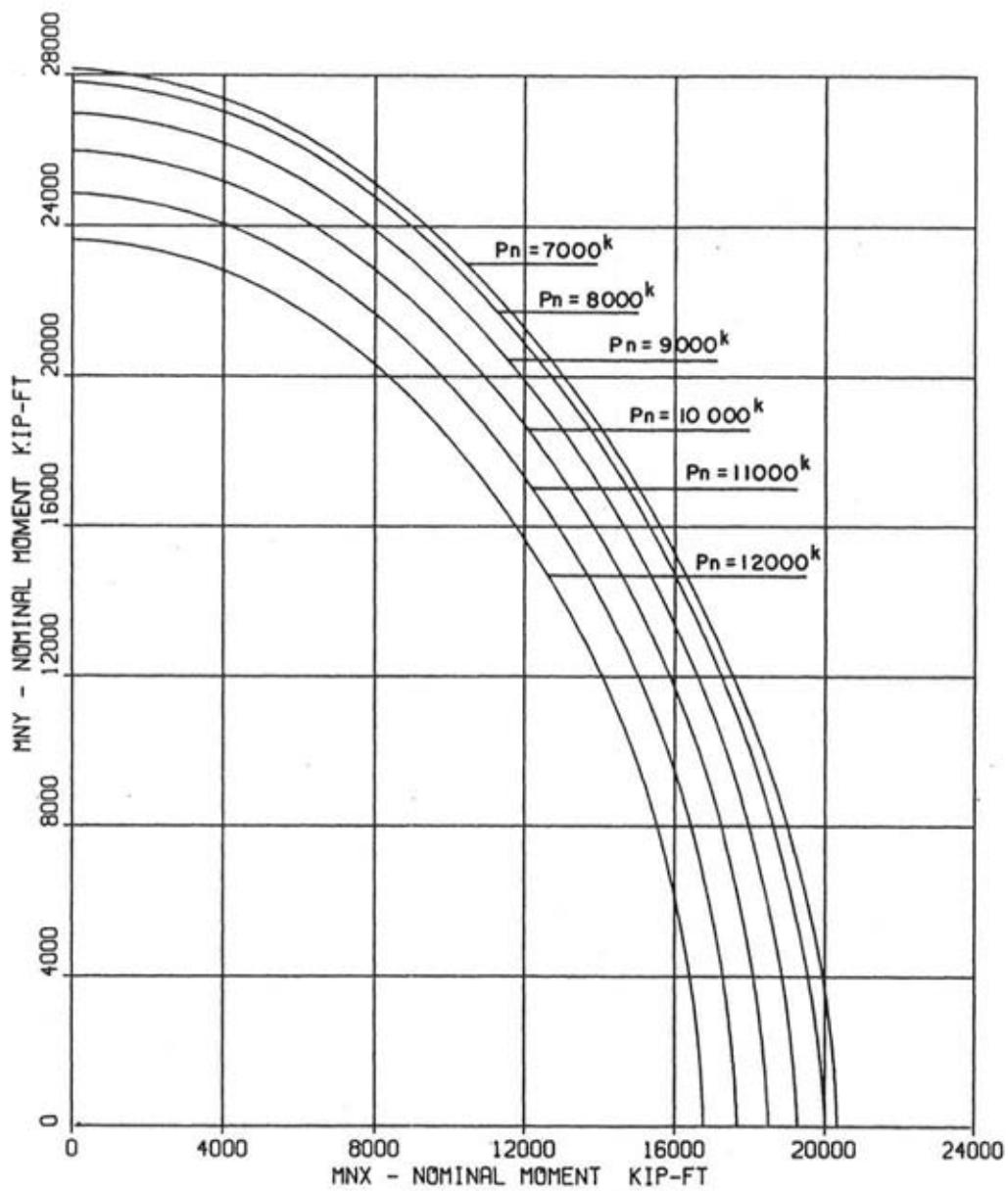
$$I_y = 175.6 \text{ ft}^4$$

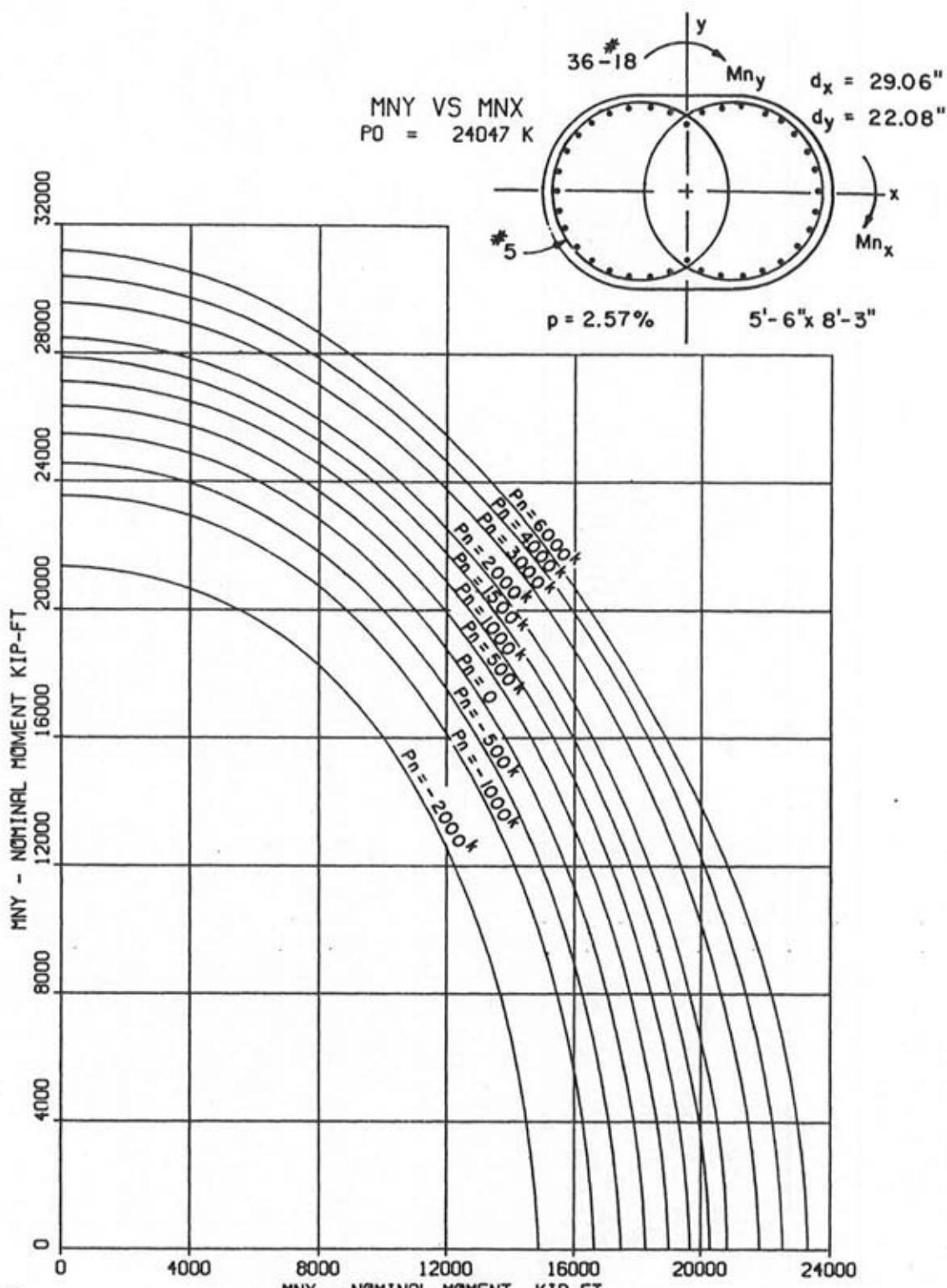
$$I_z = 258.7 \text{ ft}^4$$

MNY VS MNX
PO = 22157 K

5'-6" x 8'-3"

50-#14



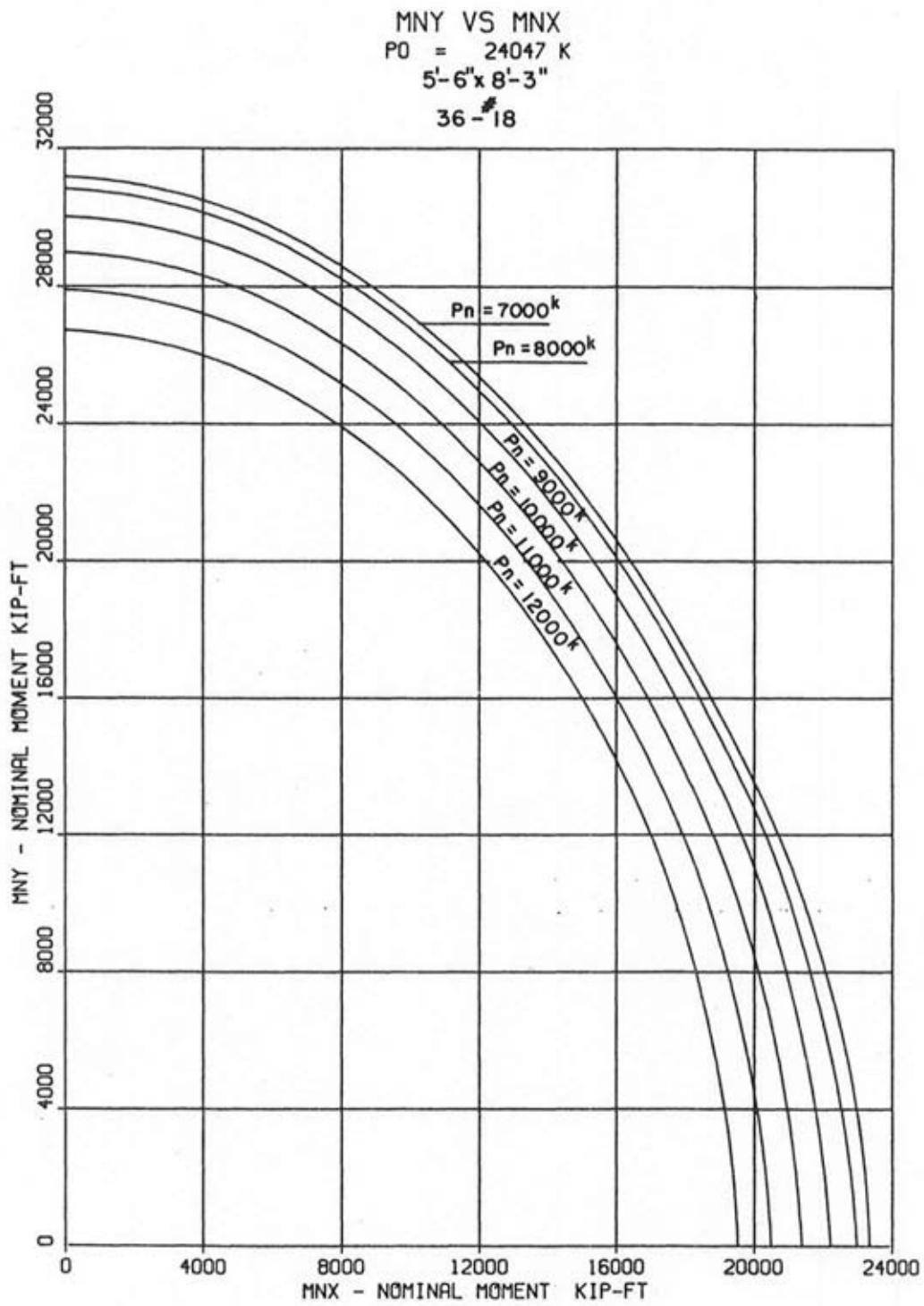


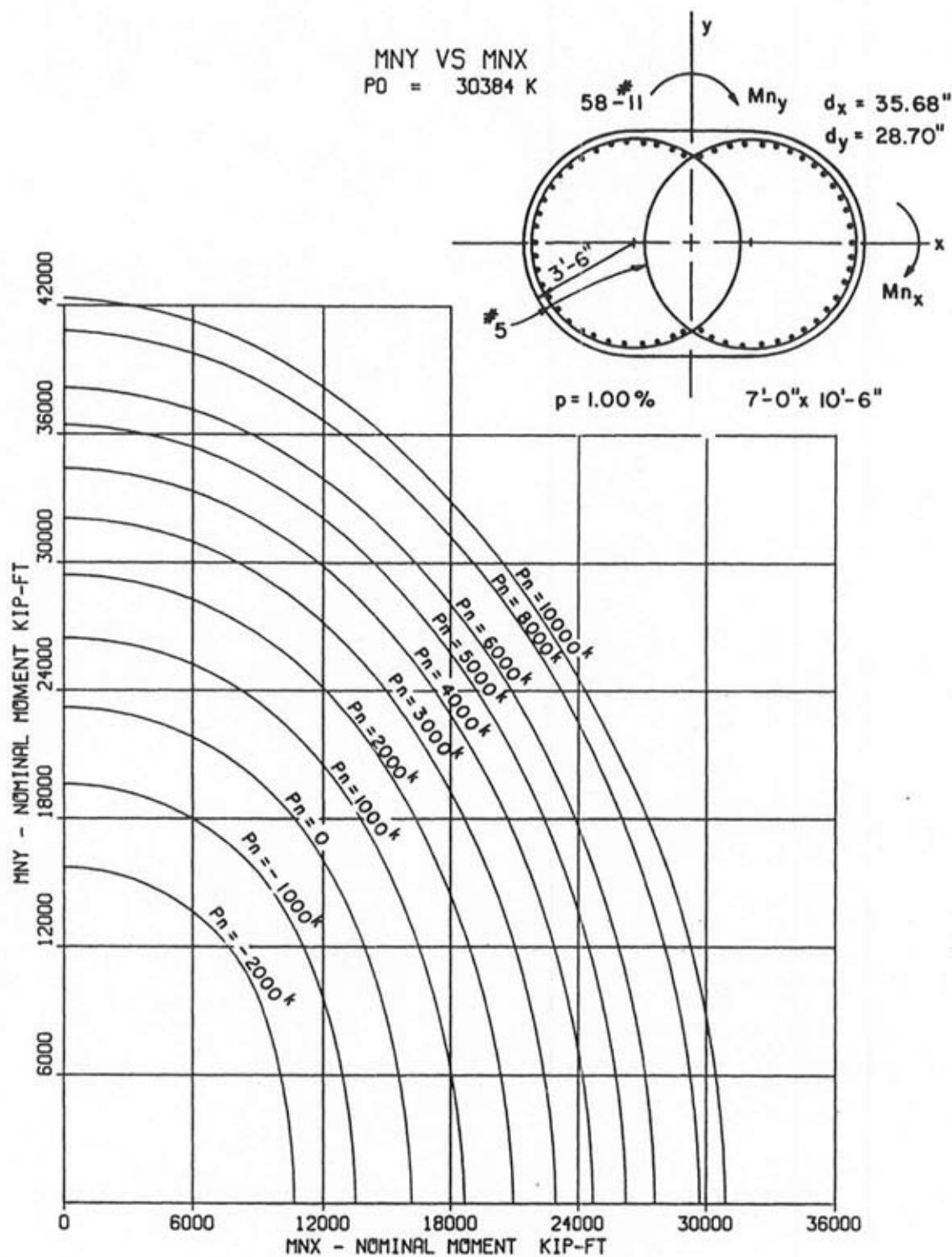
$$A = 38.9 \text{ ft}^2$$

$$I_x = 83.1 \text{ ft}^4$$

$$I_y = 175.6 \text{ ft}^4$$

$$I_z = 258.7 \text{ ft}^4$$





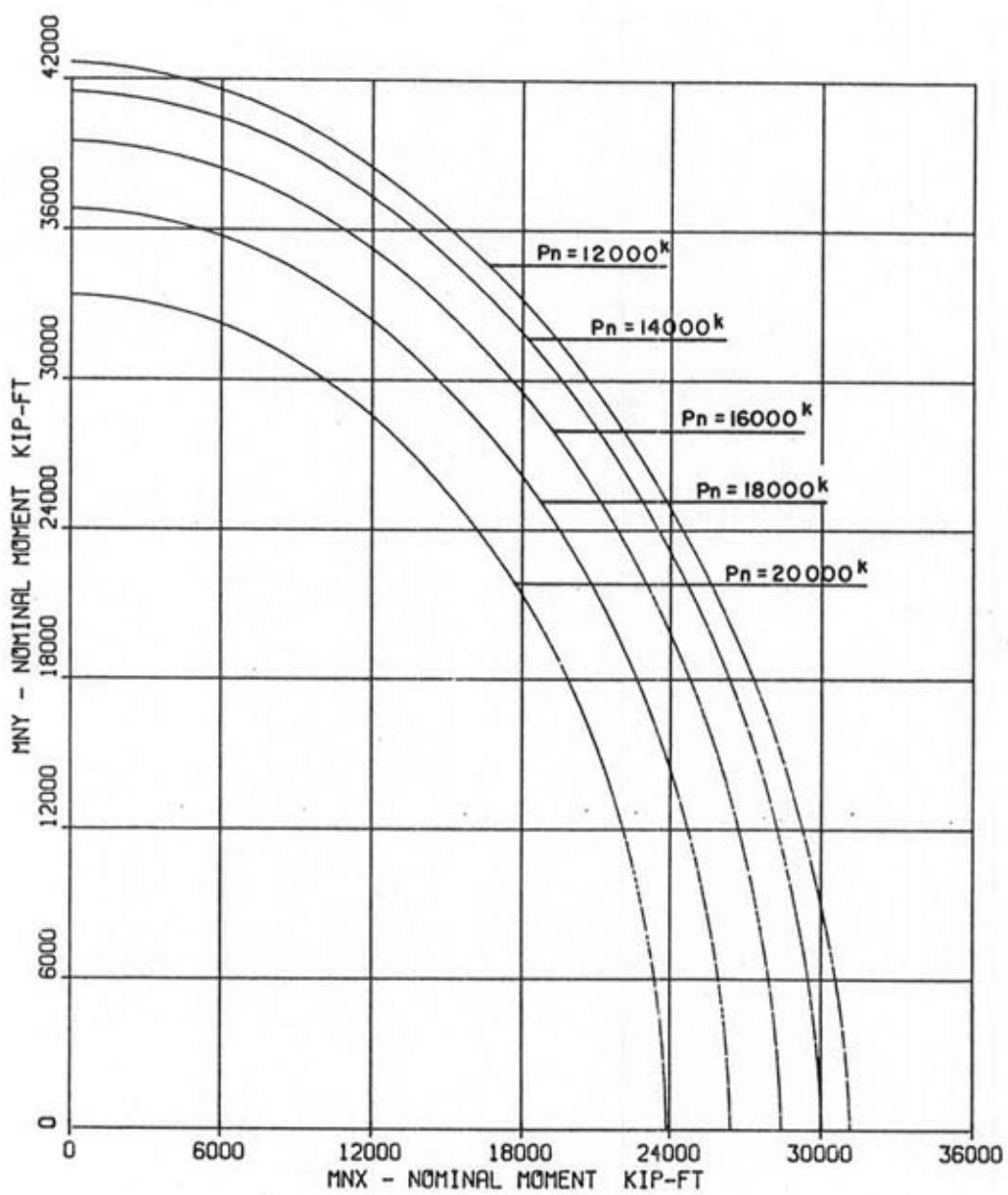
$$A = 63.0 \text{ ft}^2$$

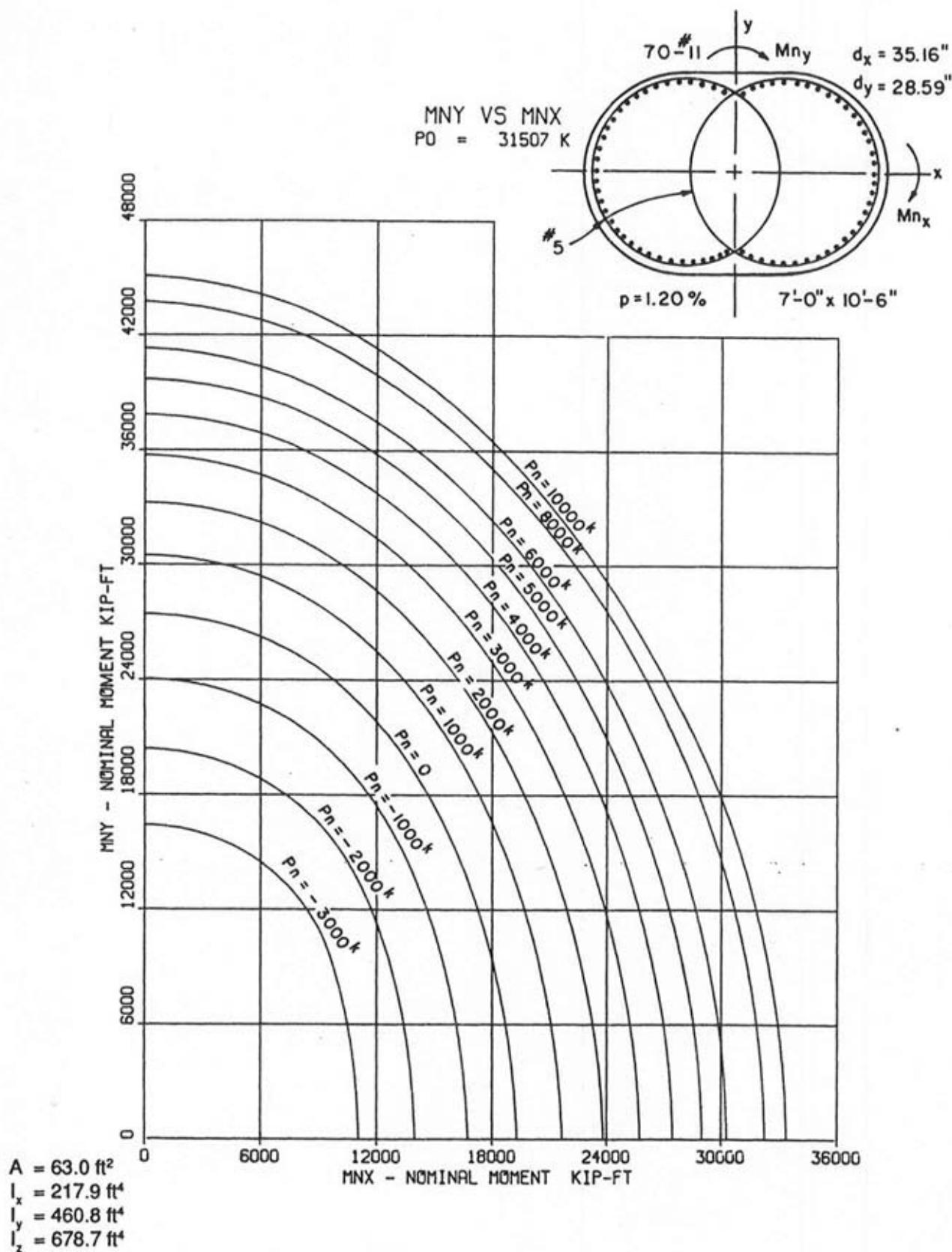
$$I_x = 217.9 \text{ ft}^4$$

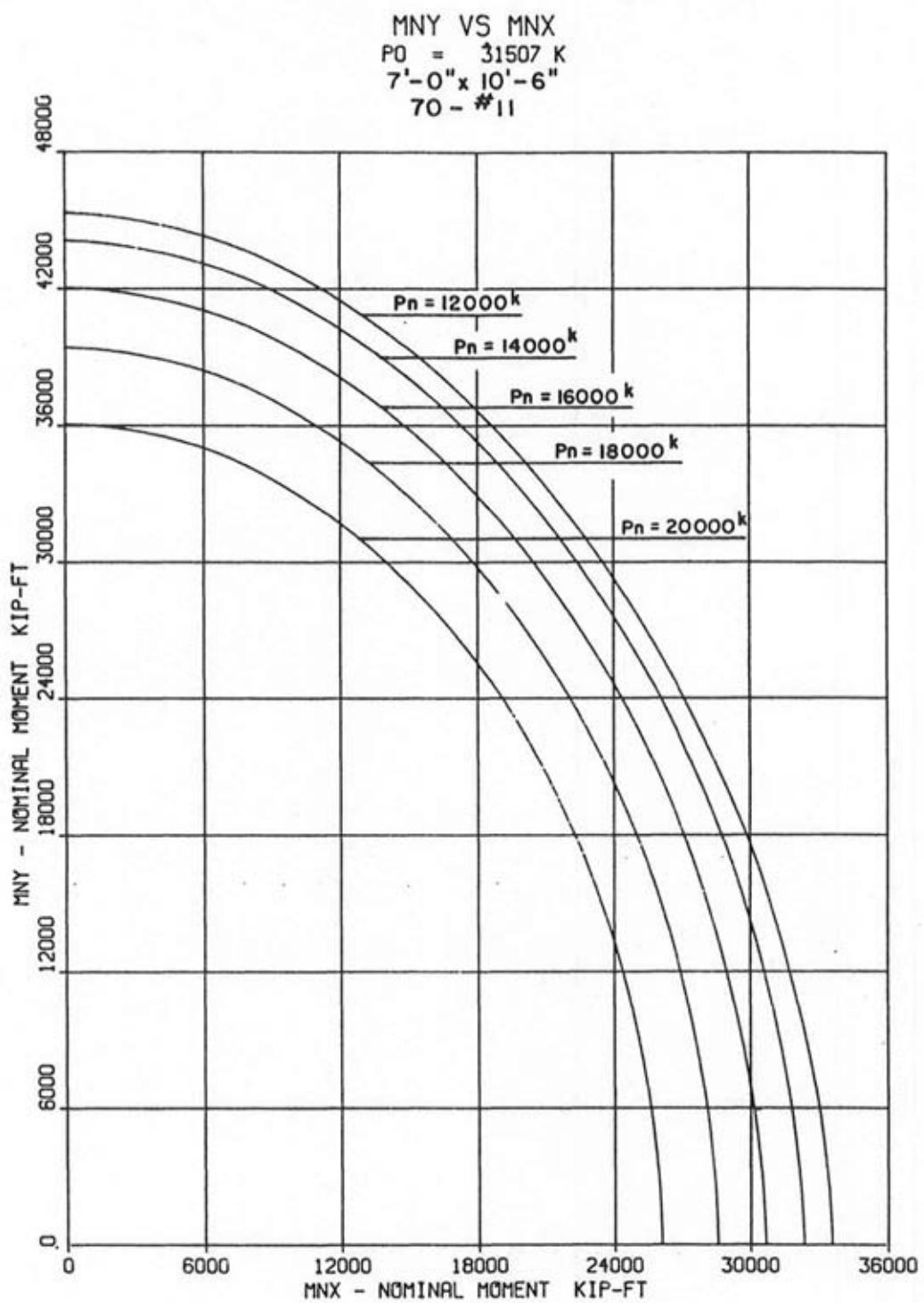
$$I_y = 460.8 \text{ ft}^4$$

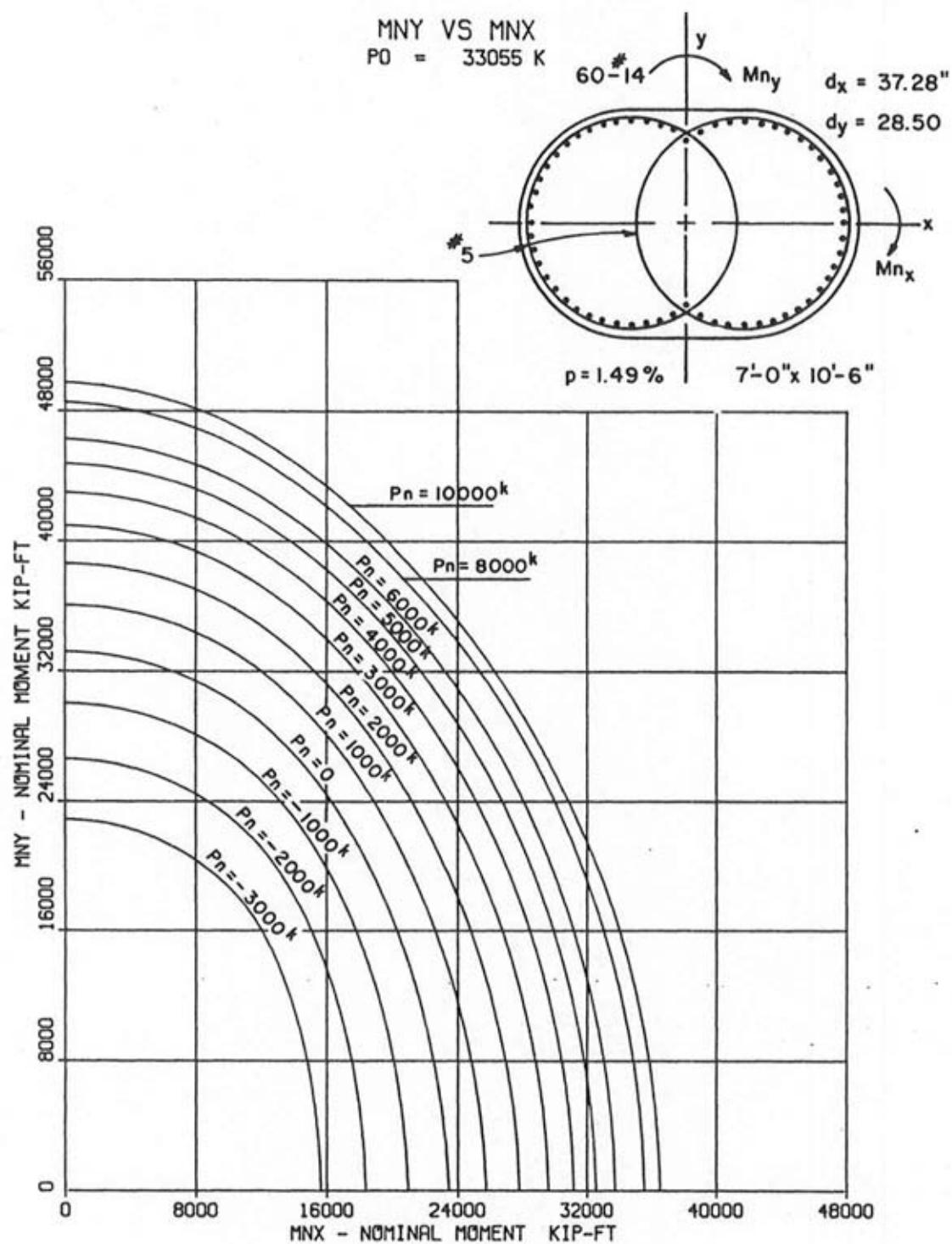
$$I_z = 678.7 \text{ ft}^4$$

MNY VS MNX
 $P_0 = 30384 \text{ K}$
7'-0" x 10'-6"
58 - #11



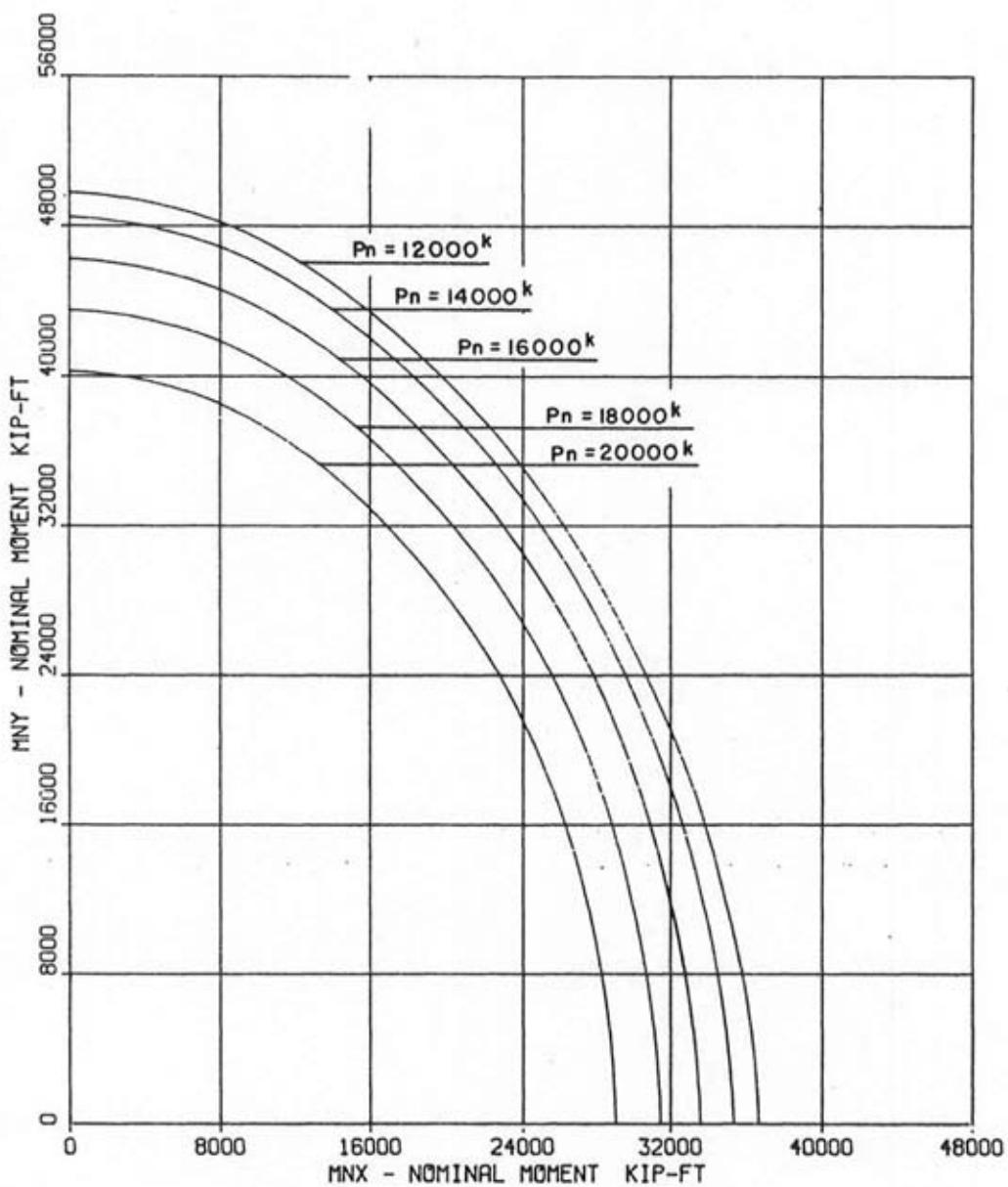


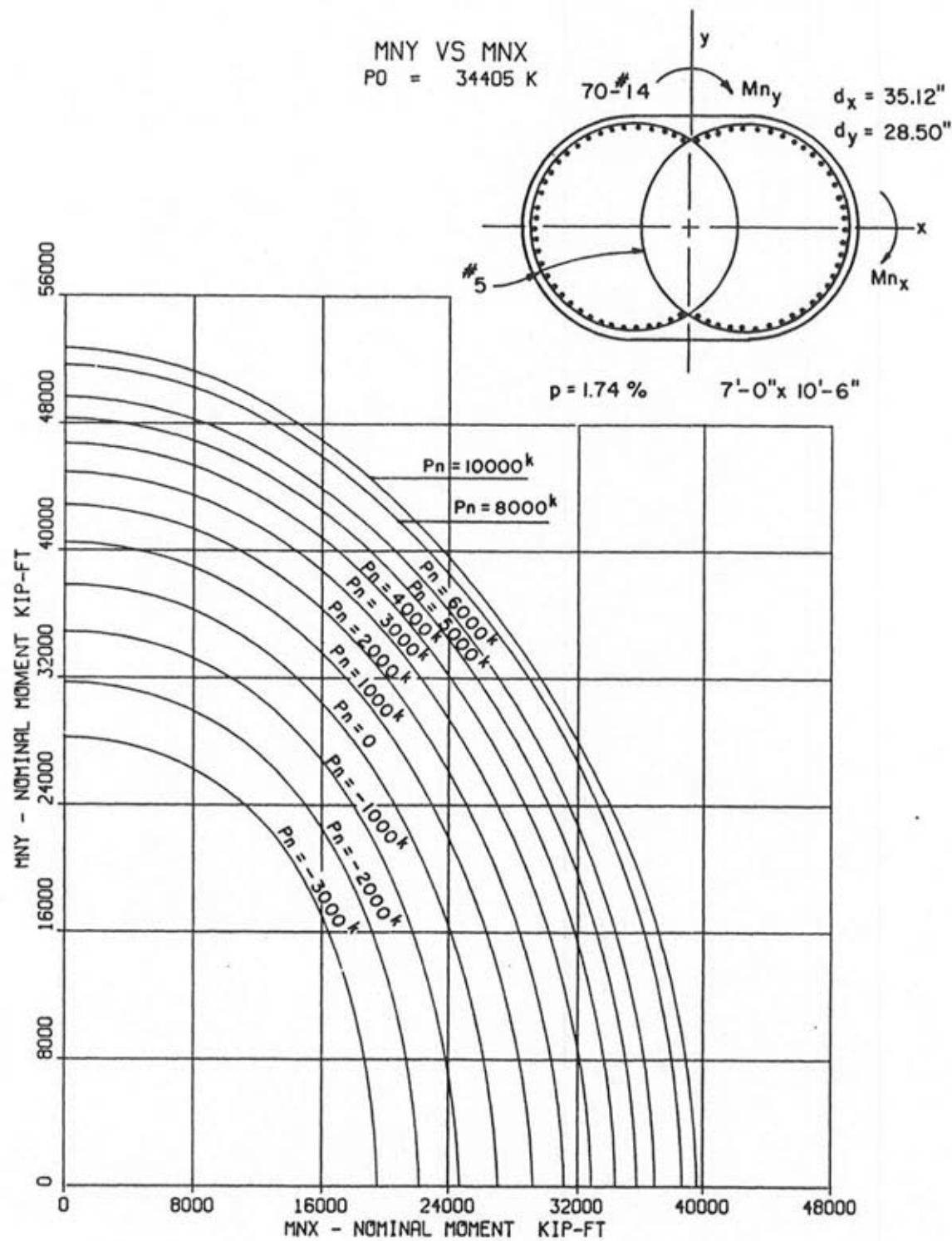




$$\begin{aligned} A &= 63.0 \text{ ft}^2 \\ I_x &= 217.9 \text{ ft}^4 \\ I_y &= 460.8 \text{ ft}^4 \\ I_z &= 678.7 \text{ ft}^4 \end{aligned}$$

MNY VS MNX
P_O = 33055 K
7'-0" x 10'-6"
60 - # 14





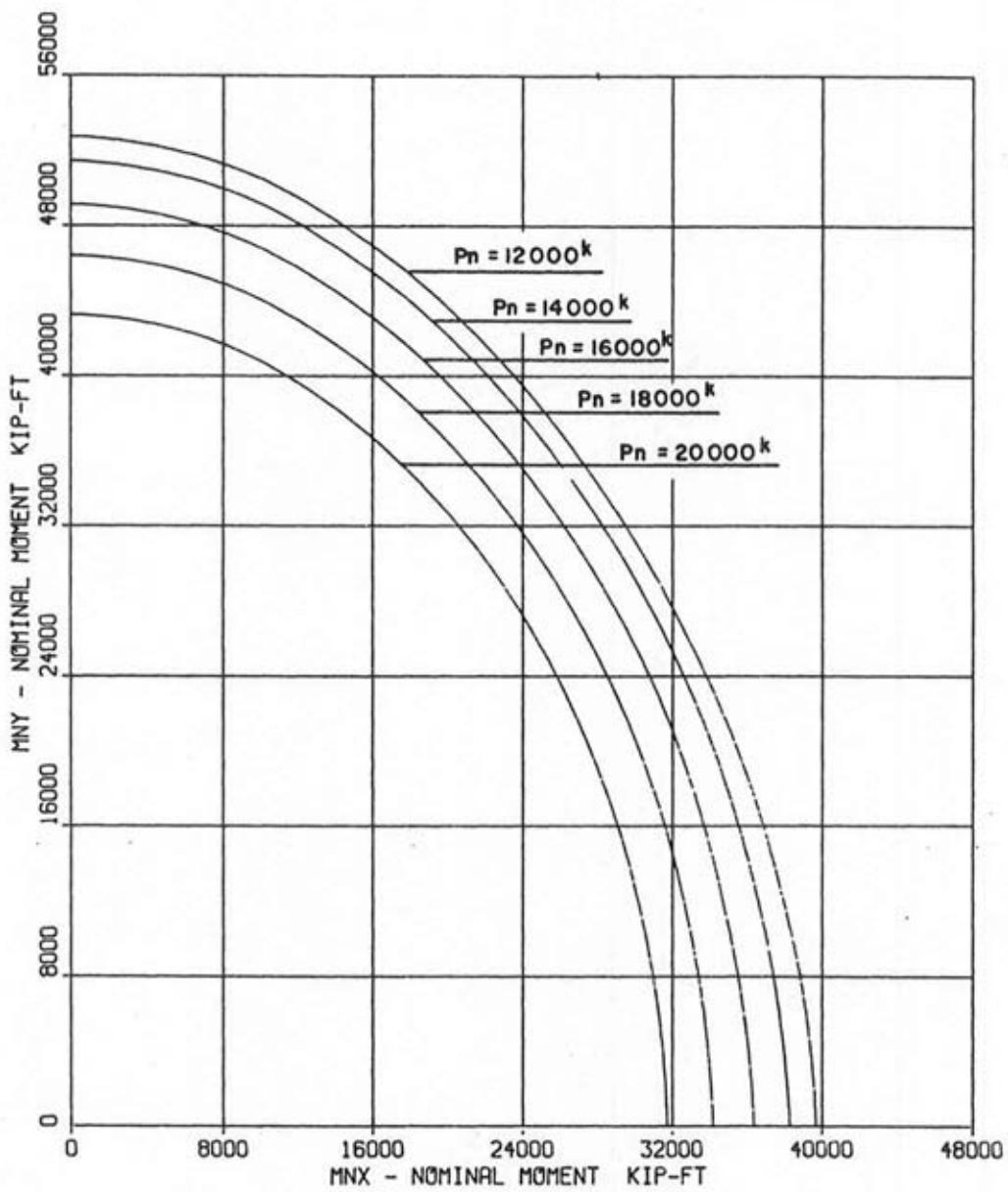
$$A = 63.0 \text{ ft}^2$$

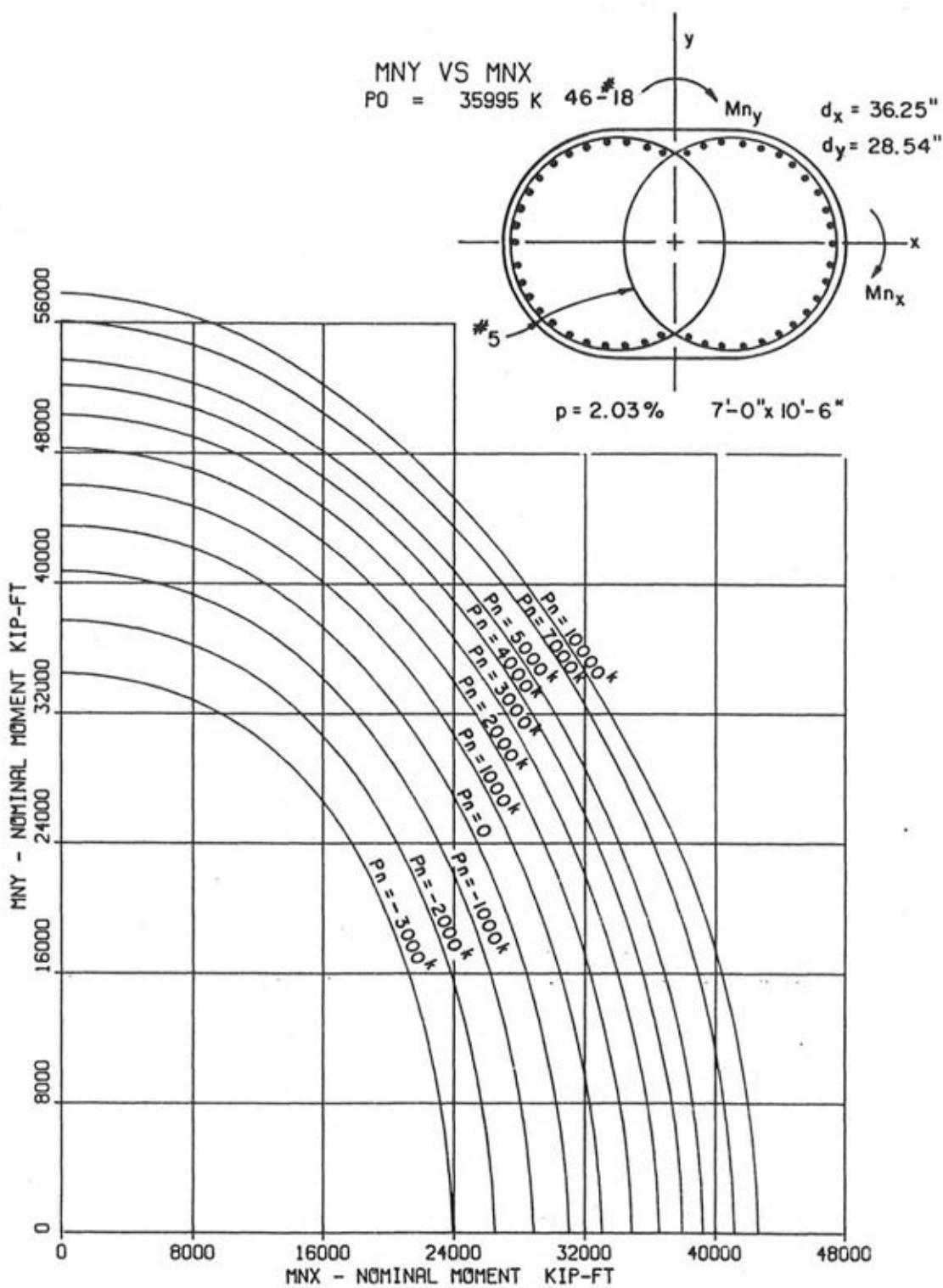
$$I_x = 217.9 \text{ ft}^4$$

$$I_y = 460.8 \text{ ft}^4$$

$$I_z = 678.7 \text{ ft}^4$$

MNY VS MNX
 $P_0 = 34405 \text{ K}$
7'-0" x 10'-6"
70 - #14





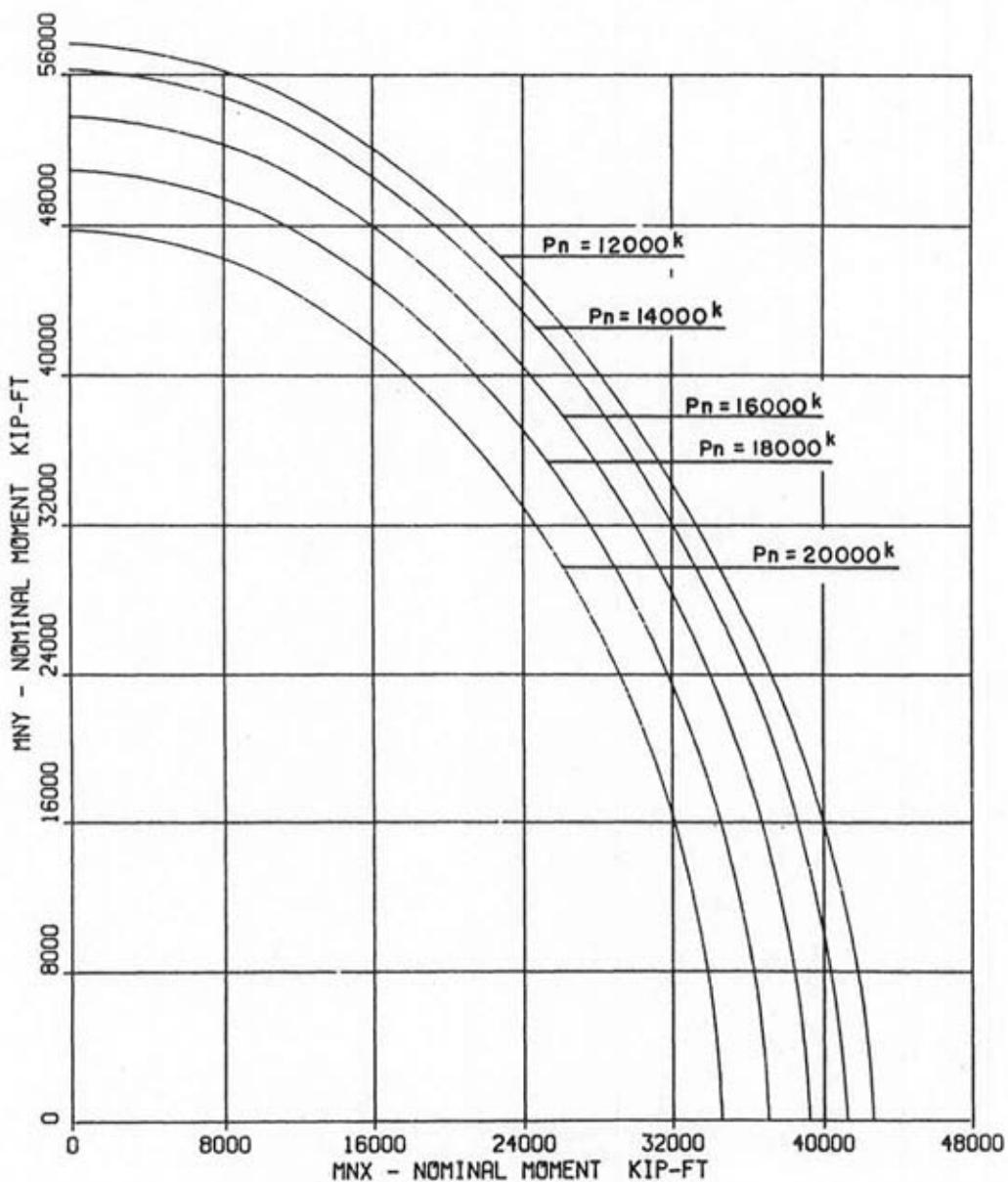
$$A = 63.0 \text{ ft}^2$$

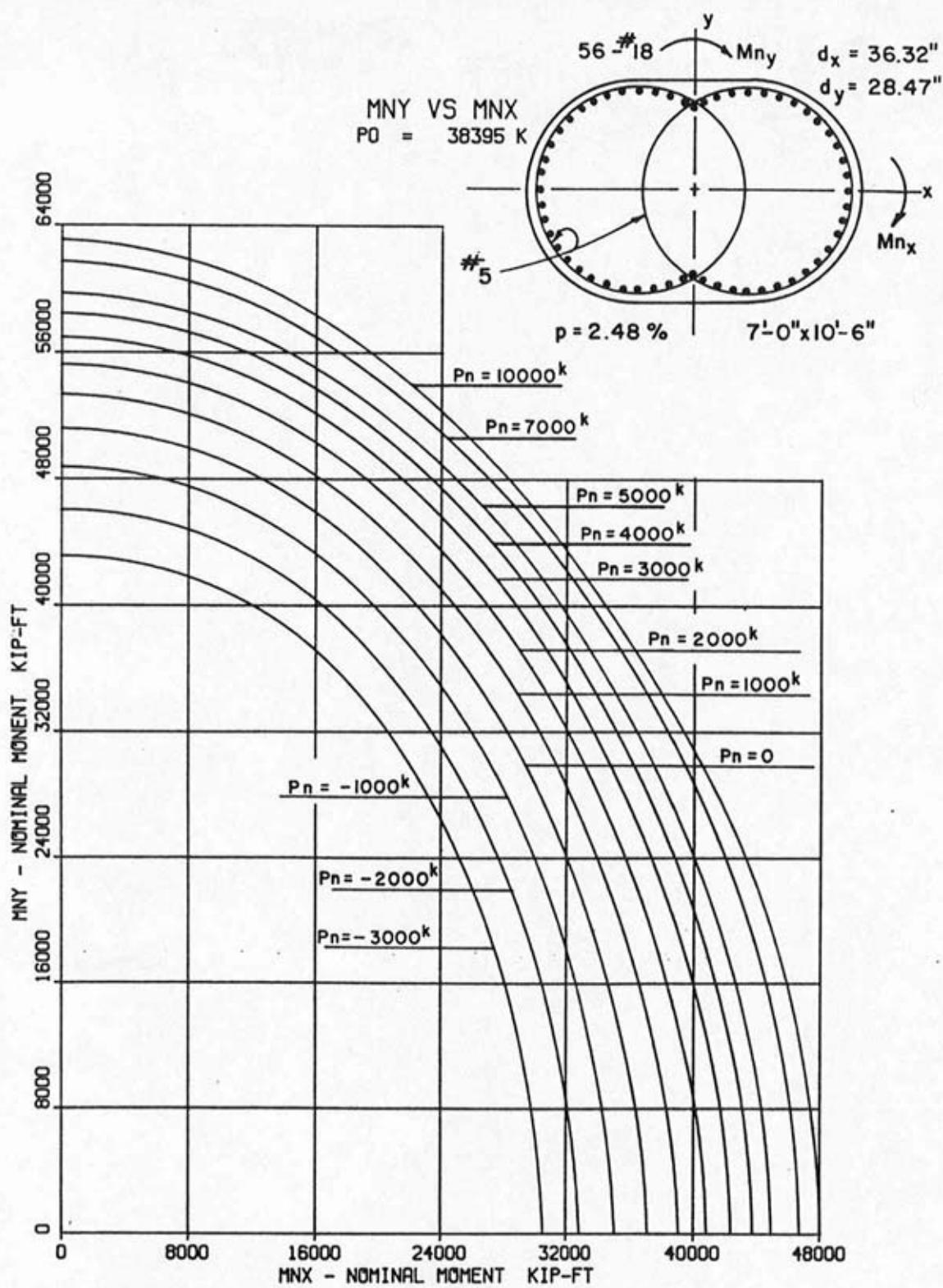
$$I_x = 217.9 \text{ ft}^4$$

$$I_y = 460.8 \text{ ft}^4$$

$$I_z = 678.7 \text{ ft}^4$$

MNY VS MNX
P₀ = 35995 K
7'-0" x 10'-6"
46 - #18





$$A = 63.0 \text{ ft}^2$$

$$I_x = 217.9 \text{ ft}^4$$

$$I_y = 460.8 \text{ ft}^4$$

$$I_z = 678.7 \text{ ft}^4$$

